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SCHOOLS OF THOUGHT
IN DEPRECIATION ACCOUNTING

by

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A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Schools of Thought in Depreciation Accounting" submitted by Delmar Perry Brooks in partial fulfilment of the requirements for the degree of Master of Business Administration.

ABSTRACT

The primary purpose of this study is to provide a better understanding of the problem of accounting for depreciation. Emphasis is placed on a comparison of the major schools of thought, which encompasses the conventional methods, the compound-interest methods, the Revco concept and the opportunity cost concept. The first three methods are usually based on original cost, whereas the final method is based on utility value.

There is no single depreciation method which is suitable for all purposes. Practical application requires that an asset's characteristics be examined in conjunction with the conditions in which the asset is employed. Factors such as the usage rate, maintenance policy, anticipated technological change and physical deterioration are determinants in the choice of a method.

From a theoretical standpoint the opportunity cost concept is probably superior to the other concepts discussed in this study. However, it is a difficult concept to apply. Theoretical matters should not be judged by their practicality, but on the basis of empirical evidence. Practical methods, on the other hand, have some theoretical basis and consequently require scientific appraisal. The main recommendation of this study is that the depreciation problem should be approached by accounting theoreticians and practicing

accountants first from the standpoint of the development of sound theory, and then from the standpoint of practical application.

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CHAPTER I

INTRODUCTION

Many an article has been written on the subject of depreciation in which the author assumed that his concept of depreciation was so obvious or so generally accepted that a clear definition of the underlying value was not necessary. Unfortunately, much misunderstanding has resulted from the failure to provide a clear definition. The question must be asked: "What kind of value are we attempting to depreciate?"

Accountants are faced with a number of problems in the determination of depreciation policy and its practical application. A clear definition of value is a mandatory first-step. Secondly, the factors which cause the value of an asset to decline during a given period must be identified, and their relative importance determined.[1]

If perfect knowledge is assumed regarding the factors which cause loss of value, there is still a problem. The loss of value must be allocated to income on some basis over the life of the asset. Unfortunately, the loss of

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[1] The types of value examined in this study include: cost-value, opportunity cost-value, user-value, et cetera. The factors which affect value, to name a few, include: physical deterioration, obsolescence, use, non-use, et cetera.

value and the earning of income are not directly related. For example, factors such as the ability of management and short term fluctuations in the demand for a product, are not directly related to asset value. Usually, depreciation and revenue are matched on the basis of the one thing they have in common--the time factor. Depreciation is determined for a specific time period and is related to revenue earned during the same time period.

Despite a general lack of agreement among accountants regarding depreciation policy, many of the theories and concepts can be grouped into general classifications. This study, after pursuing some basic questions, attempts to identify and describe the major schools of thought.

I STATEMENT OF THE PROBLEM

The primary objective of this study is to provide a better understanding of the problem of accounting for depreciation by examining the major schools of thought. Before examining the major schools of thought, however, it is necessary to attempt to find answers to such basic questions as:

1. What is the nature of depreciation?
2. What is the nature of depreciable assets?
3. What is value?
4. Why do we allocate cost?

II LIMITATIONS

This study does not present a comprehensive analysis of the theory of depreciation. The primary objective, stated earlier, is to provide a better understanding of the subject through an examination of the major schools of thought.

Price level theory and depreciation are not discussed. It is the author's opinion that the price level should be considered in terms of its relationship to the total accounting system and not restricted to a specific group of accounts.

This study is limited to a deductive examination of the topic. This is because little empirical information is presently available and such methodology for this topic is beyond the scope of a masters thesis. Basic accounting textbooks provided much of the material related to the conventional methods; whereas, accounting journals provided the contemporary concepts and ideas.

III ORGANIZATION OF THE THESIS

The body of the thesis is divided into seven chapters. Chapter II examines the meaning of the word "depreciation" and some of the reasons for the number and variety of depreciation concepts. Chapter III outlines the major, conventional methods, all of which are allocations of original cost. Chapter IV introduces the contemporary depreciation concepts which are based on the discounting

of revenues or service values of assets.[2] Chapter V presents the Reverse Compound-Interest Concept (Revco). The Revco method also ties depreciation to asset service value; however, it results in depreciation charges which are in reverse order to those provided by the compound-interest method. Chapter VI presents opportunity cost theories of depreciation, and examines the recent attempts of accountants to develop depreciation methods based on the economist's definition of value. Chapter VII provides a summary and suggestions for further research.

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[2]This concept is often referred to as the capital budgeting approach to depreciation.

CHAPTER II

THE NATURE OF DEPRECIATION

Before examining individual depreciation methods it is necessary to gain a general insight into the nature of the depreciation problem. Chapter II examines some of the definitions and concepts from which the numerous theories of depreciation have evolved. The following topics are discussed:

1. Defining depreciation;
2. The nature of depreciable assets;
3. Depreciation as a physical deterioration;
4. Depreciation as a fall in value;
5. Depreciation as a cost allocation; and
6. The maintenance of capital concept.

The purpose of Chapter II is to provide some insight into the reasons for the complexity of the subject and to provide a basis for understanding the concepts which will be examined in later chapters.

I DEFINING DEPRECIATION

If it were possible to develop a single definition for depreciation which was acceptable to all accountants and businessmen, much of the controversy which currently

exists would be eliminated. For those who enjoy argument and controversy, there would remain sufficient subject matter in the areas of valuation, estimation and application to support a full-scale debate.

In 1937 Bonbright classified depreciation into the following basic concepts:

1. A decrease in value during some defined period. This meaning is apparently the one most commonly taken in popular usage. It assumes the measurability of value either objectively as the 'market value' of the asset or subjectively as its 'value to the owner,' at two differing dates.
2. Amortization cost--the accounting concept. By this criterion the investment is considered a prepaid operating expense to be allocated by some systematic method to various fiscal periods over its useful life. In general this is also the concept adopted for tax purposes.
3. The appraisal concept of depreciation. In this method depreciation is considered as the value difference between a new asset seeking to replace the old asset, and the replacement (appraisal) value of the old. The value inferiority of the old asset is the measure of the depreciation.
4. Impaired serviceability or impaired functional efficiency. This is not a value or cost concept, but rather an engineering one. It should not be used in any connection in which monetary measurement is important.[1]

Much of the controversy over depreciation allowances has resulted from conceptual differences about the nature of depreciation. Accounting literature provides many more

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[1]H.R. Anton, "Depreciation, Cost Allocation and Investment Decisions," Accounting Research (April, 1956), p. 117. Anton quotes J.C. Bonbright (underlined) and comments thereon. Reference, J.C. Bonbright, The Valuation of Property (New York: McGraw-Hill Book Co., Inc., 1937), Ch. X.

concepts than those given by Bonbright.

Concepts are developed to meet certain objectives. As a result they will not likely satisfy other objectives. It is the opinion of many authors that all objectives cannot be met by the use of a single concept. Anton states:

> If the objective of the depreciation allowance is to measure the decrease in value during some defined period, it will be attained through amortization of cost only by chance. Likewise if the objective is to allocate to periodic revenues some measure of cost of service obtained from a specific asset, it is unrealistic to assume, or expect, that such 'depreciation' will be an adequate measure of the replacement needed.[2]

The basic objective of the cost amortization methods is to provide a systematic and rational method for allocating cost or other value over the estimated service life of the asset. However, "What are the other objectives?" Hendriksen provides a list of possibilities:

1. The decline in service value of an asset;
2. The cost of services used;
3. The net service contributions of the asset to operations; and
4. The output value of the asset's services.[3]

Possibilities one and two have the same objective even though at first glance it may appear that they are different. If the objective is to treat depreciation as a decline in

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[2] *Ibid*., p. 118.

[3] E.S. Hendriksen, *Accounting Theory*, (Homewood Illinois: Richard D. Irwin Inc., 1965), p. 311.

service value, emphasis is placed on the valuation of the asset. If the objective is to treat depreciation as the cost of services used, emphasis is placed on the valuation of services used or expired. The two methods would not be compatible in the case where there was a non-operating cost element in the depreciation charge. However, even in this case both objectives can be met if operating and non-operating depreciation charges are classified separately.

With regard to points three and four, however; consideration of the "net contribution of the services of the asset"[4] and the "output value of the asset's services"[5] may call for opposite depreciation procedures. This could be the case where the output value of an asset's services continued to rise, but where the costs of repairs, maintenance and labor costs increased at a greater rate, thus reducing the net service contributions over the years. On the other hand, if repairs increased while revenues decreased, objectives three and four may call for a rapidly declining charge method.

Obviously, depreciation takes place in a wide variety of ways. It is not necessarily a valid observation that

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[4]According to Hendriksen the net service contribution concept includes the total cost of obtaining each unit of service from an asset.

[5]According to Hendriksen the output value of an asset's services is the contribution of the asset to the total revenue of the firm.

different methods of depreciation are based on basically different assumptions or have different objectives behind them. Different types of assets used under widely varying conditions do in fact depreciate at widely divergent and varying rates.

The depreciation of an asset may depend on the nature of the demand for its product rather than on physical considerations limiting the time in which it can be used to produce a product. If the demand for a product is high and is expected to fall off rapidly, the decreasing value of the asset may justify the calculation of depreciation as a fixed percentage of diminishing book value. If the demand for a product is constant, the straight-line method may be appropriate.

II THE NATURE OF DEPRECIABLE ASSETS

Plant assets[6] may be visualized as stores of service potential, which are distinguished from current assets on the basis of the life over which the service potential will be used. Assets whose service lives exceed the usual accounting period of one year are considered to be fixed assets. There are exceptions to this general rule; for example, insurance costs which are paid in advance for several years would be designated as a prepaid expense, in the

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[6]The reference to "plant assets" or to "plant and equipment" is a narrower definition than "fixed assets." Intangible assets, noncurrent receivables, long-term investments and land are excluded.

current section of the balance sheet rather than a fixed asset in the long term section of the balance sheet.

Accounting Research Study Number Three, of the American Institute of Certified Public Accountants states:

> 'Plant and equipment' refers to those tangible assets having limited useful life and held by the business enterprise for the purpose of facilitating the creation and distribution of goods and services. The useful life of plant and equipment is limited by physical factors, such as deterioration resulting from utilization and the action of the elements and by functional factors, such as obsolescence and inadequacy. Accordingly, with utilization and the passage of time, there is a diminution in the remaining useful services which items of plant and equipment are capable of providing. The diminution when expressed in financial terms is referred to as depreciation.[7]

The above description of plant and equipment stresses one of the two main aspects in accounting for fixed assets, namely the computation of the periodic charge to net income --depreciation. The second aspect of fixed asset accounting is the valuation of the asset itself. Management requires the measurement of both aspects in order to have the proper base on which to make decisions.

Although historical cost is the most common basis for valuing plant assets there are other methods. Plant assets may be valued on the basis of opportunity cost, current market values or replacement cost; however, these

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[7] Robert T. Sprouse and Maurice Moonitz, "A Tentative Set of Broad Accounting Principles for Business Enterprises," Accounting Research Study No. 3, American Institute of Certified Public Accountants (New York: 1962), p. 32.

methods are not common in practice. In its broadest sense, plant assets may be valued on the basis of output values or input values.

The output value concept is very difficult to apply because it is difficult to relate the service of an asset to output. Usually a firm has a number of assets, all of which contribute to the output of the firm. In certain situations where the services of specific assets are sold directly, as in the case of an office building, the output valuation method is sometimes used. A common argument which is used against the output valuation method is that very little income is earned by the firm through the acquisition and holding of fixed assets. In other words, there are other factors or elements which combine with the services of plant assets to produce output.

Input values can be broken down into two categories: historical input values and current input values. The main advantage of historical input valuation is that it is objectively determined and provides a consistent, understandable basis from year to year. The figures represent the value of the fixed asset to the enterprise at the time of acquisition.

Historical cost represents a going concern value as opposed to a liquidation value. The firm expects to exist long enough to be able to receive the service benefits of the asset. The main disadvantage of historical input value

"is that it does not continue to reflect either the value of future services or the current market price of current service inputs if economic conditions or prices change in subsequent periods."[8]

"Current input values are measured best by the current cost of equivalent service",[9] however, this information may not be available. Current input values may also be measured by taking the current replacement cost of an identical piece of equipment and adjusting this cost for technological changes. Specific cost indexes are sometimes applied to historical cost figures as a method of determining the current input values.

In an economy where there are changes in price level and in the structure of prices, current input valuation would provide a better measure than historical input valuation.

III DEPRECIATION AS A PHYSICAL DETERIORATION

Physical deterioration is a factor which should be considered in establishing depreciation policy. If we consider depreciation in the narrow sense, as physical deterioration, we view assets as in the process of being

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[8] Hendriksen, _op_. _cit_., p. 291.

[9] _Ibid_., p. 293.

used up through service, or becoming less useful because of decay, rust, et cetera. In its most primitive sense, physical deterioration is not a value item at all and cannot be expressed in dollars.

Deterioration is difficult to measure. Assets deteriorate at different rates. Some assets actually improve with age, as in the case of an irrigation ditch or a wine cask. Maintenance policy can influence the rate of deterioration.

There is little information available with respect to deterioration. Business does not generally keep records in the form which can be examined for the purpose of establishing deterioration factors. Even if this information was available it would have little value where technological change was an important factor.

IV DEPRECIATION AS A FALL IN VALUE

The decline in the value of an asset may be the consequence of physical deterioration. However, in addition to physical deterioration there are other factors which cause decline in value. Goldberg states: "After an asset has been acquired something happens--it deteriorates through use, or through non-use, or it becomes obsolete or inadequate, and so on--as a result of which the change in value takes place."[10]

[10] Louis Goldberg, "Concepts of Depreciation," in Studies in Accounting Theory, ed. W.T. Baxter and Sidney Davidson, (Homewood, Illinois: Richard D. Irwin, Inc., 1962), p. 251.

The obvious question is, "What is value?" Professor Fraser distinguished four main senses in which the word value is used in economics:

1. Cost-value, ie., normal cost of production;
2. Exchange-value, ie., rate of exchange, or purchasing power, or exchange equivalent;
3. Use-value, ie., usefulness or utility; and
4. Esteem-value, ie., relative (subjective) importance.[11]

With reference to the four points, Goldberg states: "these do not represent four kinds of value; they are not different types of value (the concept), but different senses of value (the word)."[12]

Value is a subjective entity. It is necessary in using the word value to define in what context it is taken. If the word is used in a general sense, there is great danger that it will be misunderstood. Kohler states: "without qualification and clear definition, including specific and operationally feasible rules for measurement, the term (value) has only subjective significance."[13]

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[11] L.M. Fraser, Economic Thought and Language. (London: A & C Black, 1937), p. 56, Quoted by Louis Goldberg in "Concepts of Depreciation," in Studies in Accounting Theory, ed. W.T. Baxter and Sidney Davidson, (Homewood, Illinois: Richard D. Irwin, Inc., 1962), p. 251.

[12] Ibid., p. 251.

[13] E.L. Kohler, A Dictionary for Accountants, (New York: Prentice-Hall, 1952), pp. 442-443.

V DEPRECIATION AS A COST ALLOCATION

The American Institute of Certified Public Accountant's, Accounting Terminology Bulletin No. One,[14] and the American Accounting Association's Accounting and Reporting Standards for Corporate Financial Statements, 1957 Revision,[15] support the cost allocation concepts of depreciation. First we will look at the AICPA definition which is quoted below:

> Depreciation accounting is a system of accounting which aims to distribute the cost or other basic value of tangible capital assets, less salvage value (if any), over the estimated useful life of the unit (which may be a group of assets) in a systematic and rational manner. It is a process of allocation, not of valuation. Depreciation for the year is the portion of the total charge under such a system that is allocated to the year. Although the allocation may properly take into account occurrences during the year, it is not intended to be a measurement of the effect of all such occurrences.[16]

Essentially the AICPA definition is restrictive; it permits only one kind of value--value at the date of acquisition (historical cost). There is no room in the definition for theories based on current values, opportunity values,

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[14]American Institute of Certified Public Accountants, Committee on Terminology. "Review and Resume," Accounting Terminology Bulletin No. 1. in Accounting Research and Terminology Bulletins, Final Edition. (New York: 1961), p. 25.

[15]American Accounting Association, Committee on Accounting Concepts and Standards, "Accounting and Reporting Standards for Corporate Financial Statements, 1957 Revision," Accounting and Reporting Standards for Corporate Financial Statements and Preceding Statements and Supplements, (Columbus, Ohio: American Accounting Association, 1957), pp. 4-6.

[16]American Institute of Certified Public Accountants, op. cit., p. 25.

et cetera. It is the opinion of many people, including the author, that the AICPA definition is weak because it fails to accommodate all known theories.

On the other hand the AICPA definition is objective, easily understood and has general acceptance. Although the definition has been restricted to historical cost value, it is broad enough to include methods such as straight-line, compound-interest, sum-of-the-year's-digits, annuity and sinking fund.[17]

The AICPA definition is based on the going-concern postulate and the realization rule, on which Hendriksen elaborates:

> The realization rule dictates that the valuation should not exceed cost or cost less accumulated depreciation; for, if a higher valuation is used, 'unrealized' income will appear. While the going-concern postulate is relevant because it rules out the use of liquidation values in the measurement of depreciation.[18]

The AAA definition of depreciation is similar to the AICPA definition in that it is also based on historical cost value; however, the AAA definition introduces the idea of asset service potential. According to the AAA, the initial cost of an asset represents a bundle of services which will expire or be used up over the life of an asset. It states:

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[17]These methods will be described in Chapters III and IV.

[18]Hendriksen, _op_. _cit_., pp. 307-308.

> Any decline in service potential of plant and other long-term assets should be recognized in the accounts in the periods in which such decline occurs . . . . The service potential of assets may decline because of . . . gradual or abrupt physical deterioration, consumption of service potential through use even though no physical change is apparent, or economic deterioration because of obsolescence or change in consumer demand.[19]

The AAA recognition of service potential is an improvement. It provides more flexibility, in that it recognizes that conditions anticipated at the time of acquisition may not work out as expected. It allows the accountant the possibility of devising a depreciation curve which matches the pattern of the asset's service value curve.

Regardless of the definition under discussion, the question must be asked, "Why do we allocate cost?" The usual reply to the question is that we must match periodic revenues with the costs which generate these revenues. Let us carry this line of reasoning further and consider it in the context of the AAA definition. The AAA definition views an asset as the embodiment of services which are yielded up through use. The matching concept is reasonable, nevertheless it assumes that expected benefits will be proportional to an estimated usage rate. In the author's opinion this assumption may not always be appropriate.

Basically, the matching process attempts to tie

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[19] American Accounting Association, _op_. _cit_., p. 4.

together two things which are not directly related--that is, the use of long-lived assets, and the accrual of revenues. The factor used to tie them together is time. Physical deterioration and obsolescence take place over time, and revenues arise over time.

VI THE MAINTENANCE OF CAPITAL CONCEPT

In its broadest sense, the maintenance of capital concept implies that income or profit to a firm results only if the invested capital at the end of a period exceeds the invested capital at the beginning of the period (assuming that there were no capital transactions or dividend payments during the period). Again we must define the kind of value we are attempting to maintain. Are we attempting to maintain the original investment in terms of monetary values, operating capacity, or the purchasing power of our facilities in the face of a declining dollar value?

The maintenance of capital concept is broad; all depreciation concepts discussed in this study represent attempts to maintain capital. Because the capital maintenance concept is a guide which requires further interpretation, one must define the context in which he wishes to discuss it. Hendriksen states:

> The main disadvantage of the capital-maintenance concept is that it results in an all-inclusive concept of income. Unless other criteria are introduced, it does not provide a basis for determining the normal

operating depreciation separately from the abnormal losses of service potential.[20]

SUMMARY

There is no general agreement on a definition of depreciation. Even accountants suggest a variety of concepts, many of which appear to be in conflict with each other. A closer look at the problem indicates that specific objectives underlie the various concepts; and that in order to understand the concepts, it is necessary to examine the underlying objectives.

The fixed asset is described as a store of service potential acquired for the purpose of facilitating the creation of goods and services. Obviously, depreciation is the means by which expired service potential is taken into account in the records. The major problem is in valuing the fixed asset's services. An asset's services must be valued, as the preliminary step in the determination of the annual depreciation charge.

Although physical deterioration is usually an important factor in the decline of an asset's ability to produce goods and services, it is not the only factor. In a dynamic economy, obsolescence may have a greater effect on the shape of the depreciation curve. Depreciation cannot

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[20] Hendriksen, <u>op</u>. <u>cit</u>., p. 309.

be considered in terms of physical deterioration alone.

The problem of determining depreciation revolves around the problem of determining what is meant by value. Section IV lists several kinds of value, of which the distinction between them is a matter of shades of meaning. It is obvious that one's concept of depreciation must be defined within the context of one's concept of value. In the author's opinion, this is the main problem in determining depreciation policy.

The definitions of depreciation provided by committees of the AICPA and the AAA are generally interpreted as definitions based on historical cost value. Although they present the generally accepted approach, their usefulness in the determination of a comprehensive depreciation theory is restricted by their narrow approach to the concept of value.

It is difficult to criticize the maintenance of capital concept from a theoretical standpoint in that it is basically a truism. It implies that a profit can result only if invested capital at the end of a period exceeds invested capital at the beginning of a period. Depreciation accounting fits within the maintenance of capital purpose, in that it attempts to provide a proper measurement of capital services on hand and expired.

The depreciation problem is essentially a problem of valuation and allocation. The services of an asset must

be valued on some basis, whether it be cost-value, use-value, or some other kind of value. When the loss of value is determined, it must be charged against income on some basis, whether it be on the basis of time, units of production or on the basis of some other scheme. From the standpoint of allocation, depreciation policy attempts to match the cost of an asset's services against the revenues which these services produce.

CHAPTER III

CONVENTIONAL DEPRECIATION METHODS

Chapter III outlines depreciation methods which have been described in textbooks over the past thirty or forty years. They fall generally into one of the following groups:

1. The straight-line method;
2. The variable-charge methods;
3. The compound-interest methods; and
4. The decreasing-charge methods.

The conventional methods developed over the period from the turn of the century to the beginning of World War Two. They developed as the result of a growing awareness that the value of an asset's services must be taken into account in the determination of net income. Accountants attempted to develop methods of allocating the acquisition cost of assets to revenue over the asset's life. A variety of methods resulted, of which some became more popular than others. This chapter examines the better known conventional methods.

I THE STRAIGHT-LINE ALLOCATION METHOD

The annual depreciation charge produced by the straight-line method is calculated in the following way:

Annual depreciation charge =

$$\frac{\text{asset cost less estimated salvage value}}{\text{estimated life of asset}}$$

This formula, which produces constant periodic depreciation charges over the life of the asset, is based on the following assumptions:

1. Depreciation is a function of time rather than use;
2. The interest factor is zero;
3. Repairs and maintenance costs are constant over the life of the asset; and
4. The operating efficiency of the asset is constant over its life.

From the standpoint of simplicity the constant-charge method is appealing, especially when it is considered that financial information is communicated to readers with widely varying backgrounds. In this regard some textbooks state that changes in the cost pattern for reasons of whim or manipulation are more easily detectable by the average reader, when the cost pattern is constant-charge. In the author's opinion, the detection of improper charges on the basis of the information provided in the balance sheet and statement of revenue and expense, is very unlikely.

There are a number of uncertainties involved with the four assumptions stated above. Hendriksen noted, "It is difficult to find any depreciation method that is likely to take all the various factors into consideration. There-

fore, the straight-line method is often assumed to be as accurate as any other method."[1]

It is often claimed by the straight-line advocates that the straight-line method is justified because several factors tend to offset each other. For example, declining operating efficiency and increasing repair costs would be offset by increasing revenues and decreasing insurance costs. In the author's opinion, it does not seem reasonable that decreasing operating efficiency will produce increasing revenue. Furthermore, if revenues increase, it is not likely that there would be an exact offset. Paton states:

> Notwithstanding its very wide use there are serious objections to the straight-line method. The most important from a practical standpoint, is the failure of the method to take account of the declining productivity--in the economic sense--that often occurs with advancing age. Where lessening efficiency and reduced earning power can be predicted with assurance there is certainly a good reason for abandoning the straight -line procedure.[2]

A major objection to the straight-line method is in its assumption that the cost of capital is zero. The cost of capital is never zero. Ignoring the cost of capital causes the net income to have an increasing rate of return. For

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[1] Eldon S. Hendriksen, Accounting Theory, (Homewood, Illinois: Richard D. Irwin, Inc., 1965), p. 320.

[2] W.A. Paton, Asset Accounting, (New York: The Macmillan Book Company, 1952), p. 270.

purposes of illustration, let us assume that a truck costs $5,000, has an estimated service life of five years and an estimated salvage value on retirement of $500. Assume that estimated revenues and expenses, exclusive of depreciation, are $2,300 and $1,000 annually. The annual depreciation charge by the straight-line method would be $900. Table I shows the effect of the straight-line method on the rate of return on capital.

In addition to the observation, which follows from an examination of Table I, that interest costs cannot be ignored, the author is skeptical about assumptions three and four which state that repairs and maintenance costs and operating efficiencies are likely to remain constant over the life of an asset. As an asset ages, parts wear out; hence, repair and maintenance costs increase, and operating efficiency decreases.

TABLE I

STRAIGHT-LINE DEPRECIATION AND THE RATE OF RETURN

Year	Net Book Value	Reven -ues	Deprec -iation Rate	Other Expense	Total	Net Income	Rate of Return
1	$5,000	$2,300	$900	$1,000	$1,900	$400	8.00%
2	4,100	2,300	900	1,000	1,900	400	9.76
3	3,200	2,300	900	1,000	1,900	400	12.50
4	2,300	2,300	900	1,000	1,900	400	17.39
5	1,400	2,300	900	1,000	1,900	400	28.57

II THE VARIABLE-CHARGE METHOD

The variable-charge method treats an asset as a bundle of prepaid service values which are to be charged against revenue as the services are used. For example, an automobile would be depreciated in terms of miles driven and an airplane would be depreciated in terms of flying hours.

The main feature of the variable-charge method is that it accommodates fluctuations in operating conditions. The size of the depreciation charge depends upon the level of plant operations.

The variable charge method is based on the following assumptions:

1. Service value declines as a function of use rather than time;
2. Obsolescence is not an important factor in determining the life of the asset;
3. Repairs, maintenance expenses, and revenues are proportional to use; and
4. The cost of capital is assumed to be zero.

If assumptions two, three, and four are correct, then service value is properly a function of use. In the author's opinion, there is a possibility that assumptions two and three could apply, but the probability is low. The author does not agree with assumption four which states that the cost of capital is zero. Although the carrying cost

of holding capital assets may often be ignored, it cannot be assumed to be zero.

One may conclude that obsolescence is not an important factor in determining the life of a specific asset; however, in the case of most assets this would probably not be true. In a dynamic economy, such as ours, technological advance is an important factor. The rate of technological advance determines the rate of obsolescence. There is some justification for the assumption that repair, maintenance expense and revenues are proportional to use, because of the variable nature of these elements. However, this assumption cannot be applied in all cases. Some assets deteriorate through non-use.

Regardless of the depreciation method used, it is necessary to estimate the service life of an asset. Two factors which must be considered in the estimate are obsolescence and physical deterioration. If, for example, the physical life of an asset is estimated to be ten years, but its useful life due to anticipated obsolescence is five years, then the service value of the asset should be based on the five year life. The estimated value of the services received must take into account both factors. Even where obsolescence is considered in the initial calculation, there is a problem in the way in which the variable-charge method attempts to take it into account. Paton observed:

Deterioration of plant and equipment is in some degree

> a matter of age rather than actual use. Obsolescence is not retarded during slack periods. Failure to receive services in a slack period is not assurance of later increased use.[3]

III THE COMPOUND-INTEREST METHODS

Section III presents the conventional compound-interest methods which have been illustrated in textbooks over the past thirty years. Generally they are classified as follows:

A. The compound-interest method (the basic method);

B. The annuity method (derived from the basic method); and

C. The sinking fund method (also derived from the basic method).

A. THE COMPOUND-INTEREST METHOD

The compound-interest method eliminates one of the main shortcomings of the straight-line allocation method; it recognizes capital cost. The compound-interest method views the asset as a bundle of services to be obtained over the life of the asset. The periodic depreciation charge is calculated by taking the difference between the value of the assumed services at the beginning of the period

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[3] *Ibid.*, pp. 287-288.

and the value of the assumed services remaining at the end of the period, "at the rate of capitalization implicit in the situation."[4] The rate of capitalization, or the cost of capital as it is more often referred to, is the firm's cost of holding assets. Paton describes the compound-interest method as follows:

> The calculation of periodic depreciation by the so-called compound-interest procedure is launched by finding an amount which, if periodically invested in the business, would accumulate to the plant value to be absorbed during service life, at a hypothetical earning rate. The earning rate used in the calculation may be conceived as the rate necessary to attract risk capital to the undertaking at the time the asset being depreciated is acquired. Such an earning rate should not be confused with current interest rates associated with conventional investments of trust and insurance funds.[5]

For purposes of illustration, assume that a tractor was purchased at a cost of $5,000. The estimated service life is five years, at the end of which period the salvage value is nil. Assume that the compound-interest method of calculating depreciation is used and that the "estimated capital attracting earning rate" is six percent per annum.

The amount which would accumulate to $5,000 if invested each year for five years at six percent compounded annually, is $886.98. The entry for the first year would be:

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[4] *Ibid.*, p. 272.

[5] *Ibid.*, p. 272.

Depreciation cost $886.98

Allowance for depreciation $886.98

The depreciation charge for the second year is the sum of the $886.98 and interest at the rate of six percent on accrued depreciation at the end of year one. The depreciation charge for the third year is the sum of $886.98 and interest at the rate of six percent on accrued depreciation at the end of year two. Table II illustrates the above example.

TABLE II

THE COMPOUND-INTEREST DEPRECIATION METHOD

Year	Annual Depreciation Charge First Charge	Interest	Total	Accrued Deprec-iation	Net Book Value
1	$886.98		$ 886.98	$ 886.98	$4,113.02
2	886.98	$ 53.22	940.20	1,827.18	3,172.87
3	886.98	109.63	996.61	2,823.79	2,176.21
4	886.98	169.43	1,056.41	3,880.20	1,119.80
5	886.98	232.82	1,119.80	5,000.00	-
	$4,434.90	$565.10	$5,000.00		

Table II shows how the interest factor causes the depreciation charge to increase each year. It is seen in column three, that the dollar increase in the interest factor tends to accelerate each year, as the result of calculating interest on interest.

Earlier in this chapter, Table I showed the effect of the straight-line method of depreciation on the rate

of return. It was seen that, given constant revenues and current costs, other than depreciation, that earnings increased out of proportion to reality. Table III shows how the compound-interest method affects revenue and the rate of return on capital, assuming constant revenues and costs.[6]

The compound-interest method produces a constant rate of return under conditions of constant service values, shown in Table III. In the author's opinion the result produced by the compound-interest method is more realistic than the accelerated rate of return result, which is produced by the straight-line method under conditions of constant service value. Later is this chapter, decreasing service values will be presented within the compound-interest framework.[7]

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[6]The revenues and other costs are constant, as in Table I; however, the amounts have been changed so as to achieve a six percent rate of return which will be useful in later comparisons.

[7]Refer to the Decreasing-Charge Interest Method on page 38.

TABLE III

THE EFFECT OF THE COMPOUND-INTEREST DEPRECIATION METHOD ON INCOME

Year	Net Book Value	Revenues	Depreciation Expense	Income	Rate of Return
1	$5,000.00	$1,186.98	$ 886.98	$300.00	6%
2	4,113.02	1,186.98	940.20	246.78	6
3	3,172.82	1,186.98	996.61	190.37	6
4	2,176.21	1,186.98	1,056.41	130.57	6
5	1,119.80	1,186.98	1,119.80	67.18	6

B THE ANNUITY METHOD

The annuity method is a combination of the compound-interest method and a hypothetical interest charge which is added to the depreciation charge. The interest charge is calculated on the net book value at the end of each accounting period, with the debit going to depreciation expense and the credit going to unrealized interest income.

For purposes of illustration, the example of the tractor, used in Section A, will be repeated. In addition, it will be assumed that the hypothetical interest rate is six percent. The journal entries for the first two years are shown below:

Year 1

Depreciation cost	$1,186.98	
Allowance for depreciation		$386.98
Unrealized interest (6% of $5,000)		300.00

Year 2		
Depreciation cost	$1,186.98	
Allowance for depreciation		$940.20
Unrealized interest (6% of $4,113.02)		246.78

Table IV shows that the depreciation charge is constant from year to year as the result of the interest loading factor. However, the effect on net income and the rate of return is the same as the result shown in Table III.

In the author's opinion the annuity method is not an improvement on the compound-interest method. The effect of the annuity method on net income is precisely the same as the effect of the compound-interest method on net income. The annuity method inflates expense and revenue by the same amount. It also produces an unrealized revenue, when there is no assurance that an asset will recover through revenue both its costs and its anticipated return.

TABLE IV

THE EFFECT OF THE ANNUITY METHOD OF DEPRECIATION ON INCOME

			Expense						
			Depreciation						
Year	Net Book Value	Revenues	Input Value Write-off	Interest on Net Book Value	Total	Other Expense	Total	Unrealized Interest Income	Rate of Return
1	$5,000.00	$1,500.00	$886.98	$300.00	$1,186.98	$313.02	$1,500	$300.00	6%
2	4,113.02	1,500.00	940.20	246.78	1,186.98	313.02	1,500	246.78	6
3	3,172.82	1,500.00	996.61	190.37	1,186.98	313.02	1,500	190.37	6
4	2,176.21	1,500.00	1,056.41	130.57	1,186.98	313.02	1,500	130.57	6
5	1,119.80	1,500.00	1,119.80	67.18	1,186.98	313.02	1,500	67.18	6

C THE SINKING FUND METHOD

The sinking fund method combines the compound-interest method with the feature of setting aside cash or marketable securities, which with interest earnings will result in a fund equal to accumulated depreciation. The interest rate is assumed to be the firm's capital earning rate.

The tractor example used in section B will be used again. The capital interest rate is assumed to be six percent. The journal entries for the first three years are shown below:

Year 1

A.	Depreciation cost	$886.98	
	Allowance for depreciation		$886.98
B.	Tractor sinking fund	886.98	
	Bank		886.98

Year 2

A.	Depreciation cost	940.20	
	Allowance for depreciation		940.20
B.	Tractor sinking fund	886.98	
	Bank		886.98
C.	Tractor sinking fund	53.22	
	Income on fund(6% of $886.98)[8]		53.22

Year 3

A.	Depreciation cost	996.61	
	Allowance for depreciation		996.61
B.	Tractor sinking fund	886.98	
	Bank		886.98
C.	Tractor sinking fund	109.63	
	Income on fund(6% of $886.98+$940.20)		109.63

[8] Refer to Table II, column 3, page 30. It is assumed that the sinking fund deposits, which amount to $886.98 each year, will be invested to earn a rate of interest equal to the firm's capital earning rate.

The annual depreciation charges are identical to those shown in the compound-interest example; consequently, the effect on income and the rate of return on capital is the same. Interest earned on sinking fund investments does not affect the firm's net income. The sinking fund method merely hypothecates funds and earnings thereon, which would otherwise remain in the firm's general assets and revenues.

In the author's opinion the sinking fund method creates unnecessary financial rigidity. The sinking fund method forces the firm to invest a specified amount of cash, regardless of whether or not working capital and stock market conditions are favourable. Furthermore, these funds may be used more advantageously for capital investment, for debt retirement or for the payment of dividends.

A further objection to the sinking fund method relates to the assumption that the capital earning rate of the business will be equivalent to the prevailing market rate. There is little chance that the two rates would be the same over the life of an asset.

IV DECREASING-CHARGE METHODS

Section IV examines the following decreasing-charge methods:

A. The constant percentage of declining-book-value method (Diminishing-balance method);

B. The decreasing-charge interest method;

C. The sum-of-the-year's-digits method; and

D. The accelerated depreciation methods.

The above methods have been popular over the past few decades in Canada and the United States, and are in use today. Although some of their current popularity results from the tax consideration of early write-off, there are a number of additional reasons given in support of the decreasing-charge methods. Hendriksen lists some of the reasons:

1. Declining annual service values;
2. Declining operating efficiency or operating performance resulting in increases in the other operating costs;
3. Increasing repair and maintenance costs;
4. Declining cash proceeds or revenues; and
5. The uncertainty of revenues of later years because of possible obsolescence.[9]

A THE CONSTANT PERCENTAGE OF DECLINING BOOK-VALUE METHOD (Diminishing-balance method)

According to this method, a rate is found which if applied to the net book value at the beginning of each period would result in writing down the asset to its estimated salvage value over its estimated useful life. The formula for computing the rate is shown below:

$$\text{Rate} = 1 - \sqrt[n]{\frac{S}{C}}$$

where S is the salvage value, C is the original cost of the

[9]Hendriksen, *op. cit.*, p. 326.

asset and n is the years of expected life.

For purposes of illustration, assume that a barge cost $10,000 and has an estimated service life of five years, at the end of which time its salvage value will be $312.50. The rate would be calculated as follows:

$$\text{Rate} = 1 - \sqrt[5]{\frac{\$312.50}{\$10,000.00}} = 1 - .5 = .5 \text{ or } 50\%.$$

Table V shows that the annual depreciation charge is calculated by applying the 50 percent rate to the net book value at the beginning of each year.

TABLE V

COMPUTATION OF DEPRECIATION BY THE CONSTANT PERCENTAGE OF DECLINING-BOOK-VALUE METHOD

Year	Net Book Value	Annual Depreciation Charge	Accumulated Depreciation
1	$10,000	$5,000	$5,000
2	5,000	2,500	7,500
3	2,500	1,250	8,750
4	1,250	625	9,375
5	650	312.50	9,687.50
Salvage	312.50		

B DECREASING-CHARGE INTEREST METHOD

In this section the compound-interest method is examined under the assumption of declining annual service values. It is seen that the shape of the depreciation curve is

dependent upon the shape of the service value curve as well as on the interest rate and the estimated life of the asset. The difference between the compound-interest methods presented earlier, and the decreasing-charge interest method presented here, results simply from the difference of opinion about the shape of the service value curve.

For purposes of illustration, the example of the barge which cost $10,000, with an estimated service life of five years and an estimated salvage value of $313 will be used again. The annual net returns are shown below:

Year	Net Return
1	$3,377
2	2,900
3	2,015
4	1,600
5	1,000

Given these returns, the depreciable cost of $9,687 is the present value of the series of net returns at a five percent rate calculated annually.[10] The depreciation charge

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[10]The calculation of the present value at the beginning of year one is as follows:

Net Return		Factor		
$3,377	x	.95238	=	$3,217
2,900	x	.90703	=	2,631
2,015	x	.86384	=	1,740
1,600	x	.82270	=	1,316
1,000	x	.78352	=	783
				$9,687

for each period is the difference between the present value at the beginning of the period and the present value at the end of the period.

Depreciation for the year is calculated as follows:

1. The present value of net returns at the beginning of period one is $9,687;
2. Subtract the present value of the net returns at the end of period one, $6,794; and
3. The resultant depreciation charge for year one is $2,893.

Depreciation charges for years two, three, four, and five are $2,560, $1,803, $1,479 and $952 respectively.

TABLE VI

A COMPARISON OF DEPRECIATION CHARGES PRODUCED BY THE DIMINISHING-BALANCE METHOD AND THE DECREASING-CHARGE INTEREST METHOD

Year	Diminishing-Balance Method	Decreasing-Charge Interest Method
1	$5,000	$2,893
2	2,500	2,560
3	1,250	1,803
4	625	1,479
5	312	952
	$9,687	$9,687

Table VI compares the results of the diminishing-charge method described in section A of this chapter with

the results which would be obtained from the decreasing-charge interest method using the barge example. The diminishing-balance method shows a quicker write-off than the decreasing-charge interest method. Conceptually, the two methods are similar: they both produce decreasing annual charges. However, the important difference is that the decreasing-charge interest method is based on asset service values, whereas the diminishing-balance method simply writes-off aquisition cost on the basis of an arbitrary formula.

C THE SUM-OF-THE-YEAR'S-DIGITS METHOD

The sum-of-the-year's-digits method is more easily applied than the two previous methods. The annual depreciation charge is calculated by using declining fractions. "The numerator of the fraction each year is the number of years of the asset's remaining life at the start of the year, and the denominator is always the sum-of-the-digits (years) comprising the asset's original life."[11]

The example of the barge which cost $10,000, with an estimated life of five years and an estimated salvage value of $313 is used again. Table VII illustrates the method.

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[11] Thomas R. Dykman, Long-Lived Assets, (Belmont, California: Wadsworth Publishing Company, Inc., 1967), p. 49.

The sum-of-the-year's-digits method and the diminishing -balance method have much in common; they are arbitrary and inflexible. They represent techniques or formulae which are used to produce a desired effect, namely, decreasing-charge depreciation.

TABLE VII[12]

SUM-OF-THE-YEAR'S-DIGITS METHOD

Year	Book Value Jan 1	Remaining Life in Years	Deprec. Fraction	Deprec. Expense	Book Value December 31st
1	$10,000	5	5/15	$3,229	$6,771
2	6,771	4	4/15	2,584	4,187
3	4,187	3	3/15	1,937	2,250
4	2,250	2	2/15	1,291	959
5	959	1	1/15	646	313
		15	1	$9,687	

D ACCELERATED DEPRECIATION METHODS

The accelerated depreciation methods are used mainly as a device to reduce the firm's immediate net income. There can be any number of reasons for desiring a reduction of immediate net income; however, the reason usually given is that it reduces the immediate tax liability. This is not a good reason in that firms in Canada and the United States

[12] *Ibid.*, p. 50 Dykman's table format used.

are not required to use the same depreciation method for accounting purposes and for the calculation of tax liability.

Accelerated depreciation methods are sometimes defended with the argument that the future is unpredictable; therefore, the cost of assets should be written-off against revenue when there is revenue against which to write it off. In the author's opinion this argument represents a very awkward attempt at matching expired service value with the revenue it generates. An example of an accelerated depreciation method is the "double-declining-balance" method, which merely doubles the rate used by the diminishing-balance method.

SUMMARY

The depreciation methods presented in this chapter are based on historical cost value.[13] The asset is viewed as a prepaid expense which is to be allocated against revenue on a systematic basis over the life of the asset. The conventional methods are somewhat arbitrary in that they only approximate the shape of the service value curve. With the exception of the variable-charge and compound-interest methods,[14] only two estimates are required:

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[13] Reference is made to Chapter II, which examined several concepts of value.

[14] The variable-charge method requires production estimates and the compound-interest method requires the determination of the interest factor.

1. The length of the asset's life; and

2. Its salvage value at the end of its life.

The arbitrary nature of the conventional methods results from the assumptions on which each method is based. The straight-line method, for example, assumes that an asset's service values will be constant over the asset's life. This assumption is made in the face of a certain amount of evidence to the contrary which suggests that the service values of assets tend to decline with age. Furthermore, the assumption is deemed to apply equally to all assets, regardless of the variety of conditions which apply to different assets.

The main advantage of the conventional methods is that the value on which they are based (historical cost) is widely understood and generally accepted. Acquisition cost is the agreed upon price between the seller and the buyer at a point of time; it has legal validity. The conventional methods attempt to allocate this basic cost over the life of an asset in a systematic and rational manner.

The major problem with the conventional methods results from the fact that they are based on historical cost. The figures shown in the financial statements may not be meaningful in terms of current values. The balance sheet may present figures which have no relationship to the amount a firm would be willing to pay for a similar asset in similar circumstances. The depreciation charge shown in

the statement of revenue and expense may not represent the current value of expired services. The conventional depreciation methods do not meet the challenge presented by changing price levels.

CHAPTER IV

COMPOUND-INTEREST METHODS AND NET SERVICE VALUE

The basic compound-interest model (described in Section III of Chapter III) assumes that the net service values of an asset remain unchanged throughout the service life of an asset. The combination of the interest factor and level service values results in increasing annual depreciation charges and a constant rate of return on capital.

The decreasing-charge interest model (described in Section IV of Chapter III) assumes that asset service values decrease over the life of an asset. The combination of decreasing-charge depreciation and the interest factor results in a constant rate of return on capital. In the case of both the basic compound-interest model and the decreasing-charge interest model, service values are discounted so as to arrive at a constant rate of return on capital. In both examples, the service value curve and the interest factor determine the shape of the depreciation curve.

Chapter IV presents the work of several authors who have examined service value in greater depth. George Terborgh provides the groundwork for Chapter IV in a presentation which clearly shows the relationship of net service

value to capital value.[1] He stresses that service value is the all important factor in establishing depreciation policy.

Battista and Crowningshield present a method which ties depreciation policy to the considerations which were taken into account in making the initial decision to acquire the asset.[2] This approach recognizes the fact that an asset is expected to earn enough revenue to cover the initial cost of an asset, plus repair costs, and provide a return on capital investment. Battista and Crowningshield's technique of dealing with decreasing asset efficiency is the unique aspect of their approach.

In conclusion, Chapter IV examines a compound-interest method which attempts to reduce the work required in choosing a depreciation pattern. Issac Reynolds suggests that the implied net service value curves of the conventional depreciation methods should be ascertained at given rates of return; and the method which most closely approximates the asset or asset group in question be used.[3]

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[1] George, Terborgh, Realistic Depreciation Policy, (Washington, D.C.: Machinery and Allied Products Institute, 1954), p. 29.

[2] George L. Battista and Gerald R. Crowningshield, "Accounting for Depreciation and Repair Costs," NAA Bulletin, (December, 1963), pp. 239-249.

[3] Issac N. Reynolds, "Selecting the Proper Depreciation Method," The Accounting Review, (April, 1961), pp. 239-249.

I GEORGE TERBORGH

Terborgh examines the decline of capital value with age based on theoretical evidence and on empirical evidence; however, this study deals mainly with Terborgh's examination of theoretical evidence. Terborgh begins the discussion by making a clear distinction between the capital value of an asset and the sum of the realization values of its future services. He states:

> From an economic standpoint, a capital asset is nothing but a store or reservoir of valuable future services, from which alone the value of the asset derives .... The capital value of the asset is the discounted value, or present worth, of these service values, the latter in turn being the amount available for capital recovery and profit combined.[4]

Two examples are provided which support his contention that "not only is capital value normally less than the sum of future service values; its decline as the services are used up does not parallel the decline of the latter."[5]

The first example assumes an asset with a ten year life and net service values of a constant $1,000 per year. It is assumed that the capital value is always the realization value of the remaining or unconsumed services discounted at ten percent per annum, in other words, the asset is priced to yield an annual profit at that rate.

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[4]Terborgh, _op_. _cit_., p. 29.

[5]_Ibid_., p. 29.

Table VIII shows that the decline in each year's service value (column three) is a constant $1,000 or ten percent. However, the decline in capital value (depreciation) proceeds at an accelerating rate (column six), rising from 6.3 percent in the first year to 14.8 percent in the tenth year.

The second example assumes that the decline in service value is $1,900 in the first year and decreases by $200 annually over the life of the asset to $100 in the tenth year. Table IX, which illustrates the second example, shows that service values decline at a constant rate, whereas capital values decline at an accelerating rate.

The figures in both tables indicate that the pattern of decline in service values differs from the pattern of decline in capital values. Terborgh states "these examples should suffice to indicate that the dominant factor in determining the pattern of decline in capital value with increasing asset age, in other words, the pattern of depreciation, is the course of the annual service values themselves."[6] Terborgh points out that although the pattern of annual service values is the important factor in the determination of the depreciation pattern, it is not the only factor. The rate at which future services are discounted has a bearing on the depreciation pattern. He states "it follows that the main problem in the derivation of a

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[6] Ibid., p. 31.

generalized pattern of capital value erosion is to arrive first at a reasonable projection of the course of annual service values."[7]

Terborgh feels that the services of capital assets become less and less valuable with age. He stresses the following reasons for the decline:

1. Maintenance expenditures rise;
2. There is a deterioration of quality and adequacy; and
3. Competition of improved substitutes reduces quality relative to alternatives.[8]

Terborgh's empirical findings support his view that service values tend to decline with age. The results of his survey of the decline of resale value over the first half of the average service life of eight classes of capital equipment tend to indicate that values (resale values) normally run off much faster in the early years of life than in the later years. He states that broadly interpreted, his results indicate that "in the case of equipment the normal value erosion for the first third of the service life is at least one-half, and for the first half is at least two-thirds."[9]

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[7] <u>Ibid.</u>, p. 31.

[8] These are the arguments which are usually submitted by those who favour the decreasing-charge methods.

[9] <u>Ibid.</u>, pp. 44-45.

TABLE VIII

DECLINE OF CAPITAL VALUE OF HYPOTHETICAL ASSET HAVING UNIFORM ANNUAL SERVICE VALUES WHEN REMAINING SERVICES ARE DISCOUNTED AT TEN PERCENT PER ANNUM

		Sum of Remaining Service Values			Capital Value		
			Decline During Year			Decline During Year	
Year of Service	Value of Service for Year (1)	At Beginning of Year (2)	Amount (3)	Per Cent of Original Value (4)	At Beginning of Year (5)	Amount (6)	Per Cent of Original Value (7)
1	$1,000	$10,000	$1,000	10.0	$6,144	$385	6.3
2	1,000	9,000	1,000	10.0	5,759	424	6.9
3	1,000	8,000	1,000	10.0	5,335	467	7.6
4	1,000	7,000	1,000	10.0	4,868	513	8.3
5	1,000	6,000	1,000	10.0	4,355	565	9.2
6	1,000	5,000	1,000	10.0	3,791	621	10.1
7	1,000	4,000	1,000	10.0	3,170	683	11.1
8	1,000	3,000	1,000	10.0	2,487	751	12.2
9	1,000	2,000	1,000	10.0	1,736	827	13.5
10	1,000	1,000	1,000	10.0	909	909	14.8

TABLE IX

DECLINE OF CAPITAL VALUE OF HYPOTHETICAL ASSET HAVING PROGRESSIVELY DECLINING ANNUAL SERVICE VALUES, WHEN REMAINING SERVICES ARE DISCOUNTED AT TEN PERCENT PER ANNUM

		Sum of Remaining Service Values			Capital Value		
			Decline During Year			Decline During Year	
Year of Service	Value of Service for Year (1)	At Beginning of Year (2)	Amount (3)	Per Cent of Original Value (4)	At Beginning of Year (5)	Amount (6)	Per Cent of Original Value (7)
1	$1,900	$10,000	$1,900	19.0	$7,096	$1,190	16.8
2	1,700	8,100	1,700	17.0	5,906	1,109	15.6
3	1,500	6,400	1,500	15.0	4,797	1,020	14.4
4	1,300	4,900	1,300	13.0	3,776	922	13.0
5	1,100	3,600	1,100	11.0	2,854	815	11.5
6	900	2,500	900	9.0	2,039	696	9.8
7	700	1,600	700	7.0	1,343	566	8.0
8	500	900	500	5.0	778	422	6.0
9	300	400	300	3.0	355	264	3.7
10	100	100	100	1.0	91	91	1.3

Terborgh visualizes very few situations in which straight-line depreciation would be appropriate. His theoretical and empirical observations support decreasing-charge depreciation. However the important feature of Terborgh's conclusion is not the shape of the depreciation curve, but the relationship of service value to depreciation.

II GEORGE L. BATTISTA AND GERALD R. CROWNINGSHIELD

Battista and Crowningshield's philosophy is based on the considerations management must take into account in deciding whether or not to acquire an asset. They state:

> One thing seems certain. In order that a proper matching of revenue and cost be effected, it is necessary that consideration be given to the profitability of an asset. If it is to be profitable, it must produce revenues large enough to cover the following:
> 1. The initial cost of the asset;
> 2. A return on capital invested; and
> 3. Repair costs.[10]

Battista and Crowningshield's concept is similar to Terborgh's concept, however their approaches are slightly different: Battista and Crowningshield dwell more on the factors which affect service value--such as repair costs and decreasing efficiency, whereas, Terborgh is more interested in the relationship of the depreciation curve to the service value curve. The most interesting aspect of the Battista and Crowningshield method is their equation which

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[10]Battista and Crowningshield, *op. cit.*, p. 26.

makes it possible to experiment with the factors which affect service value.

The following example ignores repair costs for the moment and assumes a return to the purchaser of seven percent on capital invested. An assumed investment of $30,000, with a ten year life could be justified only if the annual revenue to be derived from the asset would have a present value of $30,000, at seven percent. The formula is expressed as follows:[11]

$$\$30{,}000 = \frac{x}{1.07} + \frac{x}{(1.07)^2} + \frac{x}{(1.07)^3} \cdots \frac{x}{(1.07)^{10}}$$

The value of x is $4,271. This is the amount of annual income necessary to justify the purchase of an asset at $30,000 when money is worth seven percent. Depreciation is then the value of each of the above terms in reverse order, as shown in Table X.

Repair costs are now brought into the discussion and are assumed to occur in the following pattern:

End of Year	Amount
2	$4,000
4	4,000
5	6,000
6	4,000
8	4,000
	$22,000

Battista and Crowningshield hold the view that repair costs should be accrued, thus resulting in even charges against

[11] Ibid., p. 26.

TABLE X[12]

DEPRECIATION ON A TEN YEAR, $30,000 INVESTMENT

ASSUMING A SEVEN PERCENT RETURN ON INVESTMENT

IGNORING REPAIR COSTS

Year	Net Income Before Depreciation	Return on Investment*	Depreciation**
1	$4,271	$2,100	$2,171
2	4,271	1,948	2,323
3	4,271	1,785	2,486
4	4,271	1,611	2,660
5	4,271	1,425	2,846
6	4,271	1,226	3,045
7	4,271	1,013	3,258
8	4,271	785	3,486
9	4,271	541	3,730
10	4,271	280	3,995
			$30,000

* 7% of net book value.

** The annual depreciation charge equals the difference between net income and the rate of return on net book value.

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[12] *Ibid.*, p. 26.

income over the life of an asset. For example, the above repair costs which total \$22,000 would be spread at the rate of \$2,200 per annum over the ten year life of an asset.

If we assume that repair costs are accrued at \$2,200 per annum for ten years, at first glance it might appear that the new formula would be:

$$\$30{,}000 = \frac{x-\$2{,}200}{1.07} + \frac{x-\$2{,}200}{(1.07)^2} \ldots \frac{x-\$2{,}200}{(1.07)^{10}}.$$

However, it is necessary to modify the left side of the equation in order to consider the additional investment required by the incurrance of repair costs:

$$\$30{,}000 + \frac{\$4{,}000}{(1.07)^2} + \frac{\$4{,}000}{(1.07)^4} + \frac{\$6{,}000}{(1.07)^5} + \frac{\$4{,}000}{(1.07)^6} + \frac{\$4{,}000}{(1.07)^8} = \$45{,}816.74.$$

The right side of the equation would remain unchanged:

$$\frac{x}{1.07} + \frac{x}{(1.07)^2} + \frac{x}{(1.07)^3} \ldots \frac{x}{(1.07)^{10}}$$

The value of x is \$6,523.27, which represents the annual income to be produced by the asset to recover the initial cost, the repair costs and a seven percent return on capital invested. Table XI shows the effect of the introduction of repair costs.

Tables X and XI provide a picture of constant annual net income over the ten year life of the asset. The introduction of repair costs in table XI caused a slightly

TABLE XI[13]

DEPRECIATION ON A TEN YEAR, $30,000 INVESTMENT

ASSUMING A SEVEN PERCENT RETURN ON INVESTMENT

INCLUDING REPAIR COSTS

Year	Net Income Before Depreciation	Return on Investment	Anticipated Repair Cost	Depreciation
1	$6,523	$2,100	$2,200	$2,223
2	6,523	1,790	2,200	2,533
3	6,523	1,739	2,200	2,584
4	6,523	1,404	2,200	2,919
5	6,523	1,326	2,200	2,997
6	6,523	1,382	2,200	2,941
7	6,523	1,302	2,200	3,021
8	6,523	937	2,200	3,386
9	6,523	826	2,200	3,497
10	6,523	424	2,200	3,899
	$65,230	$13,230	$22,000	$30,000

[13] *Ibid.*, p. 26.

different depreciation pattern than in table X, nevertheless it remained an increasing-charge pattern.

Earlier, repair costs were brought into the equation. Now, the loss of asset efficiency with age will be considered. It will be seen that, with the introduction of the loss of efficiency factor, the Battista and Crowningshield concept becomes similar to the Terborgh concept. It is now a depreciation concept based on asset service values which produce a decreasing-charge depreciation pattern.

In the example provided by Battista and Crowningshield, it is assumed that an asset will lose ten percent of its efficiency each year, beginning with the second year and continuing through to the eighth year. The following modification is necessary:

$$\$45{,}816.74 = \frac{x}{1.07} + \frac{.90x}{(1.07)^2} + \frac{.80x}{(1.07)^3} + \frac{.70x}{(1.07)^4} + \frac{.60x}{(1.07)^5} + \frac{.50x}{(1.07)^6} + \frac{.40x}{(1.07)^7} + \frac{.30\,x}{(1.07)^8} + \frac{.30x}{(1.07)^9} + \frac{.30x}{(1.07)^{10}}$$

The value of x is $10,393.70. Table XII shows the effect of the introduction of the loss of efficiency factor.

Table XII shows declining annual net income and depreciation figures, whereas in the previous two tables these figures were constant from year to year. The shape of the two curves, as such, is not important: the important consideration is that we now have a concept which accommodates

TABLE XII[14]

DEPRECIATION ON A TEN YEAR, $30,000 INVESTMENT

ASSUMING A SEVEN PERCENT RETURN ON INVESTMENT

INCLUDING REPAIR COSTS AND

INCLUDING A TEN PERCENT, LOSS OF EFFICIENCY FACTOR

Year	Net Income before Depreciation	Return on Investment	Anticipated Repair Cost	Depreciation
1	$10,394	$2,100	$2,200	$6,094
2	9,355	1,519	2,200	5,636
3	8,315	1,251	2,200	4,864
4	7,276	756	2,200	4,320
5	6,236	580	2,200	3,456
6	5,197	603	2,200	2,394
7	4,150	562	2,200	1,388
8	3,118	310	2,200	608
9	3,118	393	2,200	525
10	3,118	203	2,200	715
	$60,277	$8,277	$22,000	$30.000

[14] *Ibid.*, p. 27.

variable asset service values. Of secondary importance is the recognition that asset service values probably decline with age.

III ISSAC N. REYNOLDS

Reynolds' concept is similar to the concepts presented earlier in this chapter. He projects the pattern of net service values for the major asset groups and then determines a pattern of depreciation charges based on the net service value pattern. Reynolds outlines his philosophy as follows:

> Entrepreneurs do not, . . . , buy future net services at "face" or "par"--they buy the asset to make a profit; hence, conceptually, they discount the bundles of future net services which they purchase. Therefore, by inference, an <u>ideal depreciation</u> method is one which allocates cost in such a way as to produce a uniform return on remaining unamortized investment in all periods at the rate of return implicit in the original transaction by which the asset was acquired.[15]

Most authors would agree with the general meaning of the phrase "net service value"; however, there is little agreement on the relative importance of the factors which determine net service value. Reynolds defines net service value to mean "that part of 'real' revenue contributed directly by the plant asset, less all operating costs other than depreciation, which are properly chargeable against revenue."[16] In Reynolds' opinion, the course of net service

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[15]Reynolds, <u>op</u>. <u>cit</u>., pp. 243-244.

[16]<u>Ibid</u>., p. 240.

values would depend mainly on four factors:

1. The trend of operating costs: (including repairs);
2. The physical efficiency of an asset;
3. The amount of competition which would be expected from improved alternatives; and
4. The expected rate of asset use.[17]

The noteworthy aspect of Reynolds' paper is his "back door" approach to the selection of a depreciation method. He suggests that management should ascertain the kinds of net service value curves at given rates of return which are implied by the different formalized methods, such as:

1. The sinking fund method;
2. The straight-line method; and
3. The sum-of-the-year's-digits method.

From this, management would select the formalized method which would most closely approximate the service value curve of the asset group in question. Management would need only a generalized knowledge of the shape of the service value curve.

Reynolds illustrates his approach by projecting the service value curves implied by each of the above three methods. The calculations are based on a ten year asset which cost $10,000 and which promises to earn ten percent on net investment. The results of his calculations are shown in the three charts which follow. The conclusions are

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[17] _Ibid._, p. 240.

interesting:

1. The sinking-fund method calls for a level series of net service values, yet the pattern of depreciation is an increasing one;
2. The straight-line method requires a slight downward schedule of net service values (one that declines each year by the rate of return multiplied by the equal annual depreciation charge); and
3. The sum-of-the-year's-digits method demands a markedly decreasing pattern of net service values with a slight sag in the middle (the resultant depreciation curve is a sharply decreasing one which has a uniform rate of decrease each year).

Reynolds' method has merit from the standpoint of practicality. His generalized approach simplifies the problem of forecasting asset service values. Reynolds states that "even if the formalized depreciation method does not fit precisely the actual life history of particular assets, results in aggregate for all plant assets should be reasonable provided that the broad pattern applicable to major groups are wisely chosen."[18]

Reynolds' paper does not add any new theoretical knowledge beyond what Terborgh and Battista and Crowningshield presented. Reynolds merely attempts to affect a compromise

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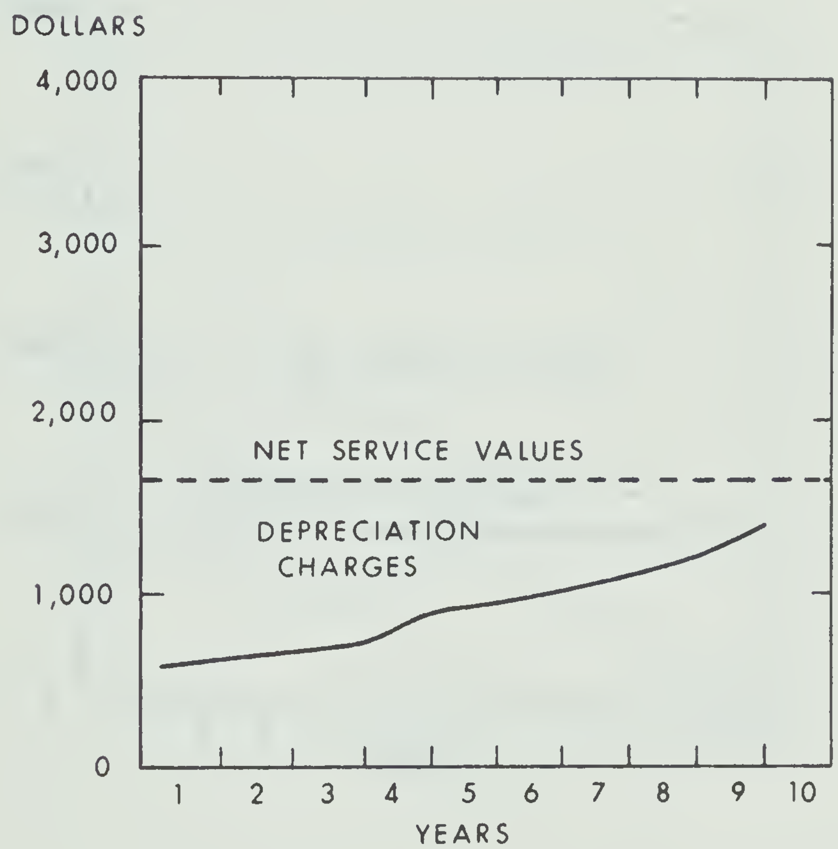
[18] Ibid., p. 248.

FIGURE I[19]

ANNUAL DEPRECIATION CHARGES AND NET SERVICE VALUES IMPLIED BY THE SINKING-FUND METHOD FOR AN ASSET COSTING $10,000 WITH A TEN-YEAR LIFE AND NO SALVAGE VALUE, ASSUMING A TEN PERCENT RATE OF RETURN.



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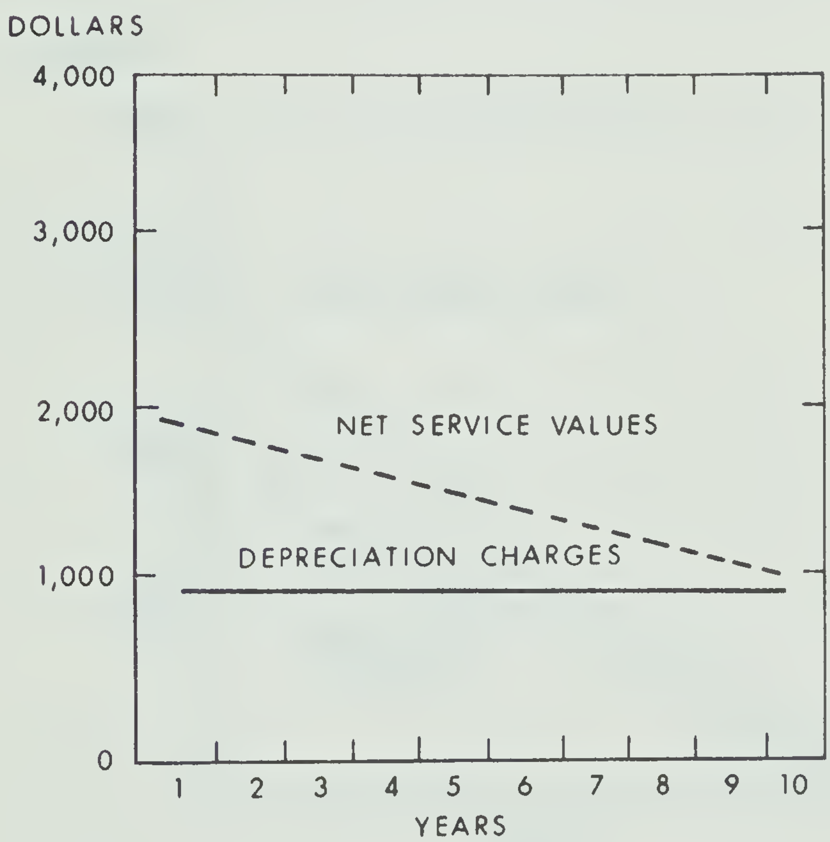
[19] Ibid., p. 245.

FIGURE II[20]

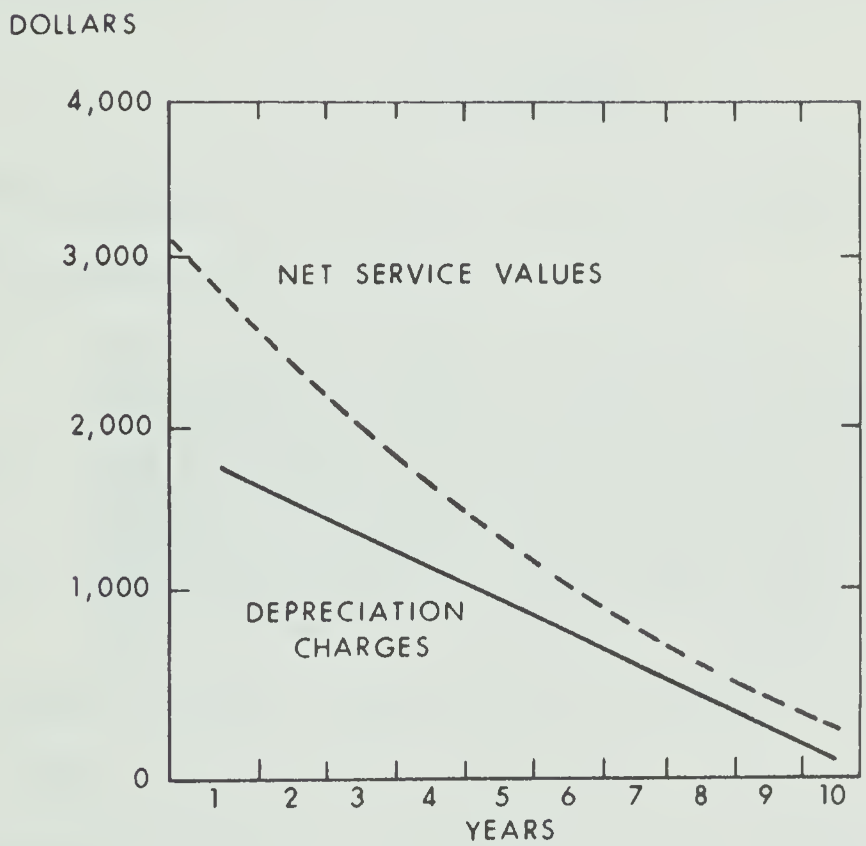
ANNUAL DEPRECIATION CHARGES AND NET SERVICE VALUES IMPLIED BY THE STRAIGHT-LINE METHOD FOR AN ASSET COSTING $10,000 WITH A TEN-YEAR LIFE AND NO SALVAGE VALUE, ASSUMING A TEN PERCENT RATE OF RETURN.



[20] *Ibid.*, p. 245.

TABLE III[21]

ANNUAL DEPRECIATION CHARGES AND NET SERVICE VALUES IMPLIED BY THE SUM-OF-THE-YEAR'S-DIGITS METHOD FOR AN ASSET COSTING $10,000 WITH A TEN-YEAR LIFE AND NO SALVAGE VALUE, ASSUMING A TEN PERCENT RATE OF RETURN.



[21]Ibid., p. 246.

between the concept of depreciation based strictly on discounted service value, and the formalized methods (conventional methods). His purpose for doing this is to retain the simplicity of the formalized methods and at the same time to relate depreciation to service value. In the author's opinion, the extent to which one should compromise depends largely on the difficulties encountered in obtaining information about assets. Reynolds' compromise should be judged on the basis of its practical advantage in a given situation.

IV SUMMARY

The compound-interest methods examined in this chapter share the following characteristics:

1. The original cost of the asset represents the present discounted value of a constant stream of services plus the discounted value of scrap;
2. The carrying value (book value) of the asset always represents the discounted value of the remaining stream of services and scrap value; and
3. The depreciation charge each year represents the input value of the asset's services in that year.[22]

Future annual depreciation charges are determined at the time the asset is acquired. The net service values of an asset provide for both the annual depreciation charge and the profitability factor. The interest rate used in the calculations is the firm's capital earning rate. It is implied that this rate encompasses the recovery of the

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[22]Hendriksen, op. cit., p. 323.

initial cost of the asset, plus repair and maintenance costs, and provides a return on capital investment.

Terborgh provides illustrations which clearly show the relationship of service value to capital value. He emphasizes what the other authors in the chapter imply--that is, that the shape of the net service value curve determines the shape of the depreciation curve. The empirical part of Terborgh's work is referred to only briefly in this chapter; however, it is worth mentioning that his findings indicate that asset service values decline rapidly in the early years of an asset's life and tail off in the latter years.

Battista and Crowningshield approach the subject in a slightly different manner than Terborgh. Terborgh projects a net service value curve and then calculates depreciation, whereas Battista and Crowningshield concentrate more on the factors which affect the net service value curve.

Reynolds provides a practical approach for the application of the compound-interest idea. He suggests that management should ascertain the kinds of net service value curves at given rates of return, which are implied by the different formalized methods, and that management should select the formalized method which most closely approximates the service value curve of the asset group in question. Undoubtedly, his approach has practical merit.

The depreciation methods examined in this chapter

are superior to the conventional interest method, which assumes that the service values of an asset are constant from year to year. Chapter IV places greater emphasis on the nature of service value and its relationship to depreciation. The factors which determine the value of an asset's services, such as repair costs, asset efficiency and obsolescence will not likely produce constant service values from year to year, in every case. There is considerable support for the opinion that service values tend to decline with age.

The logical approach to the problem of determining the depreciation pattern is to first determine the future course of service values. In order to do this, it is necessary to examine the factors which determine the value of an asset's services. The methods examined in Chapter IV properly take into account service value, in the determination of depreciation.

CHAPTER V

THE REVERSE COMPOUND-INTEREST CONCEPT (REVCO)

During the past few years, a number of articles have been published on the Revco method of calculating depreciation. In order to explain the nature of the Revco method it will be compared to the compound-interest method, using the following example. Assume that a machine was purchased for $1,000, with an expected life of five years and with no anticipated salvage value at the end of its life. Assume that the company is averaging a ten percent return on capital. Income tax is ignored at this time.

The compound-interest method calculates depreciation as follows:

1. First, calculate the amount which, if invested annually for five years at ten percent compounded annually, would accumulate to $1,000: the amount is $163.80.
2. Then determine annual depreciation charges by adding interest calculated on accrued depreciation at the beginning of a period to the basic charge of $163.80.

With reference to table XIII, it is seen that the depreciation charge for year three equals ten percent of $343.98,

plus \$163.80, which is \$198.19.

The Revco method, in its simplest form, calculates depreciation as follows:

1. First determine the discount values for \$1,000 at ten percent compounded annually at the end of each year for five years:

$$
\begin{aligned}
\text{Year } 1 &= \$1{,}000/1.10 &&= .90\\
\text{Year } 2 &= \$1{,}000/(1.10)^2 &&= .83\\
\text{Year } 3 &= \$1{,}000/(1.10)^3 &&= .75\\
\text{Year } 4 &= \$1{,}000/(1.10)^4 &&= .68\\
\text{Year } 5 &= \$1{,}000/(1.10)^5 &&= .62\\
&\text{Total} && \underline{3.78}
\end{aligned}
$$

TABLE XIII

DEPRECIATION CHARGES ON A FIVE YEAR, \$1,000 ASSET, ASSUMING A TEN PERCENT RETURN ON INVESTMENT, CALCULATED BY THE COMPOUND-INTEREST METHOD

	Annual Depreciation Charge			
Year	First Charge	Interest	Total	Accrued Depreciation
1	\$163.80		\$ 163.80	\$ 163.80
2	163.80	\$ 16.38	180.18	343.98
3	163.80	34.39	198.19	542.17
4	163.80	54.22	218.02	760.19
5	163.80	76.01	239.81	1,000.00
	\$819.00	\$181.00	\$1,000.00	

2. Then the total discount value is treated as 100 percent with the yearly discount values representing a percentage of the total.

Year 1 =	24.0%
Year 2 =	21.8
Year 3 =	19.8
Year 4 =	18.0
Year 5 =	16.4
	100.0%

3. The percentages shown in two, above, are then applied to the cost of the asset to arrive at the annual depreciation charges, noted on Table XIV.

The Revco method results in annual depreciation charges which are in reverse order of magnitude to the charges provided by the compound-interest method.

This chapter presents articles written by Dixon and Bierman, who favour the Revco approach, and articles written by two authors who do not favour the Revco approach. The basic argument for Revco is that distant services are worth less than immediate services and consequently should not command as large a charge against income. Support for the argument is twofold:

1. Future services are worth less than immediate services because of the discount factor; and
2. The value of an asset's services tends to decline with age (deterioration factor).

Revco is favoured by some decreasing-charge advocates because they feel that it produces a "controlled" method. For example, the sum-of-the-year's digits method and the diminishing balance method are not controlled in the sense that the depreciation curves produced by these methods only vaguely approximate the shape of the service value curve.

The Revco advocates feel that Revco overcomes the imprecision of the conventional methods because of its closer tie with the net service value curve.

TABLE XIV

DEPRECIATION CHARGES ON A FIVE YEAR, $1,000 ASSET ASSUMING A TEN PERCENT RETURN ON INVESTMENT CALCULATED BY THE REVCO METHOD

Year	Depreciation	Per Cent of Total
1	$ 240	24.0%
2	218	21.8
3	198	19.8
4	180	18.0
5	164	16.4
	$1,000	100.0%

The Revco method is rejected by many authors because they feel that it produces a rate of return on book value which increases over the life of the asset at an unrealistic rate. The major reason for the increasing rate of return is that the cost of capital is ignored.

I R.L. DIXON[1]

Professor Dixon favours decreasing-charge depreciation;

[1]R.L. Dixon, "Decreasing Charge Depreciation--A Search For Logic," The Accounting Review, (October, 1960), pp. 590-597.

however, he is not willing to accept decreasing-charge methods which merely approximate actual circumstances. He is critical of the conventional depreciation methods because he states:

1. We cannot control the curve; and
2. We really don't know whether its predetermined course makes any sense.[2]

He holds the view that a depreciable asset will suffer a decline in annual service value over its life. He refers to this phenomenon as the "deterioration of periodic services" and to the rate at which it diminishes as the "deterioration factor." His deterioration factor includes "declining physical service, declining economic service, declining demand, and declining second hand market."[3]

Dixon's philosophy is stated below:

1. An asset is an embodiment of services to be rendered through time.
2. Implicit in the purchase price of the asset is the cost of all services to be rendered.
3. The rational purchaser places a higher valuation on the services immediately to be rendered than he does on those which will be rendered in the more remote future.
4. If the cost of the asset is viewed as a summation of the present values of the bundle of services, then as the earlier layers of service are consumed they have higher price tags, and higher cost depreciation, than do the later services. Depreciation thus follows a declining curve.[4]

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[2] *Ibid.*, p. 591.

[3] *Ibid.*, p. 591.

[4] *Ibid.*, p. 592.

Dixon provides the following example to illustrate his theory. He assumes an asset which will cut labour cost by $100 per year and which has a two-year life. He assumes, also, that the buyer must earn twenty percent before taxes to justify such a capital expenditure. The twenty percent rate is then used to discount the $100 value of the future services for each of the two years. The sum of the two discounted values ($83.33 for the first year and $69.44 for the second year, or $152.77) would be the maximum amount which would be offered by the buyer. If the asset is acquired at that figure, the amounts to be charged off as depreciation in each of the two years logically should be the discounted values of the services (the savings) in those two years--for example, $83.33 and $69.44 respectively. Thus the depreciation would be charged off according to a declining curve, even though the savings or service received is the same each year.

Dixon's theory is based on two factors: the "deterioration factor" and the "interest factor." These two factors "combine to produce a slope the steepness of which is governed by the magnitudes of the interest factor and the deterioration factor combined."[5]

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[5] Ibid., p. 593.

II HAROLD BIERMAN JR.[6]

Professor Bierman presents a Revco concept which is somewhat different than Dixon's concept. Bierman treats the returns from the original investment as periodic investments in themselves and claims that it is necessary to compute both interest costs and revenues on these periodic investments.

Dixon's method results in decreasing-charge depreciation and increasing percentage returns on investment when the deterioration factor is assumed to be zero. Bierman's method also results in decreasing-charge depreciation; however, the inclusion of interest cost results in a constant percentage return on investment.

For purposes of illustration, Bierman assumes an investment which cost $24.87 and which is expected to earn cash proceeds of $10 for each of three years (the $10 is equal to revenues less all incremental expenses other than depreciation). The salvage value at the end of three years is assumed to be nil.

He assumes that the cost of capital is ten percent, therefore the present value of the proceeds is equal to the cost of the investment. At the beginning of the first

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[6] Harold Bierman, Jr., "Depreciable Assets-Timing of Expense Recognition," The Accounting Review, (October, 1961), pp. 613-618.

period, the firm is willing to pay:

$9.09 for the proceeds of the first year ($10 x .909)
$8.26 for the proceeds of the second year ($10 x .826)
$7.51 for the proceeds of the third year ($10 x .751).

Tables XV and XVI are taken from Bierman's paper.[7]

TABLE XV

COMPUTATION OF INTEREST COSTS AND REVENUES

1 Period	2 Basic Invest -ment	3 Interest Year 1 10% (2x10%)	4 Invest -ment plus Interest (2+3)	5 Interest Year 2 10% (4x10%)	6 Invest -ment plus Interest (4+5)	7 Interest Year 3 10% (6x10%)
1	9.09	.91				
2	8.26	.83	9.09	.91		
3	7.51	.75	8.26	.83	9.09	.91
Interest Revenue		2.49		1.74		.91

TABLE XVI

COMPUTATION OF NET INCOME AND RETURN ON INVESTMENT

Period	Cash Proceeds	Deprec- iation	Interest Costs	Interest Revenue	Net Income	Return on Investment
1	10.00	9.09	.91	2.49	2.49	.10[8]
2	10.00	8.26	1.74	1.74	1.74	.10[9]
3	10.00	7.51	2.49	.91	.91	.10[10]
		24.86	5.14	5.14	5.14	

[7] Ibid., p. 615.

[8] The $24.86 is the initial outlay. 2.49/24.87=.10.

[9] (8.26+.83)+(7.51+.75) = 17.35. 1.74/17.35 = .10.

[10] 7.51 +.75 +.83 = 9.09. .91/9.09 = .10.

In year one, the interest cost of the $9.09 investment is $.91, and the total interest earned on the three investments is $2.49. Net income is calculated as follows:

Net proceeds		$10.00
Add interest earned		2.49
		$12.49
Deduct:		
Depreciation	$9.09	
Interest cost	.91	10.00
Net Income		$ 2.49

The net income for year two is $1.74 and for year three is $.91.

Bierman explains his theory as follows:

> This depreciation procedure accomplishes several objectives. The income figure of each period is undistorted. The zero income results because the investment earned a return of 10%, which is equal to the cost of capital. This zero income is consistent with certain economic theories of profit which require recognition of capital costs before recognizing profit. The return on investment is 10% for each period if the net income amounts are used. Thus the system allows a measure of income and return on investment undistorted by the mere passage of time or the accident of the period being measured.[11]

Bierman then asks the question "How do we deal with the situation where the cost of capital does not equal the rate of return?"

First, it is not necessary to consider a situation where the cost of capital exceeds the rate of return, because the net proceeds discounted back would be less than the investment cost, and therefore the investment would not be undertaken. This leaves us with the situation where the

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[11]Bierman, op. cit., p. 615.

cost of capital is less than the rate of return.

For purposes of comparison the previous example is used; however, now the cost of capital is assumed to be six percent. The rate of return remains at ten percent.

The solution to the problem is to compute the present value of the cash flows using the cost of capital (six percent). This results in the present value of cash flows being greater than the cost of the investment. The difference is debited to the investment account and credited to an account titled "Unrealized Profit."

The present value of the cash flows using a six percent rate is $26.73, and the unrealized profit is $1.86 (subtracting the cost of the investment, $24.87, from the present value of the cash flow, $26.73). The write-off of unrealized profit to earnings is accomplished by using six percent as the cost of capital and subtracting this from the result of the calculation of the rate of return using ten percent. This yearly amount, so calculated, is considered to be realized profit and is added to earnings.

Bierman considers unrealized profit to be an extra incentive to invest. He states:

> This amount which we have called 'Unrealized Profit' may represent an 'excess' incentive to invest. The investment should be undertaken if the present value of the cash flow is equal to or greater than the cost of the investment. Since the present value of the cash flows is greater than the cost this investment may have excess incentive.[12]

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[12] Ibid., p. 617.

Bierman adds a feature to the Revco method with his treatment of annual service values as individual investments. However, by contrast to the Dixon method, he implies that he does not accept the viewpoint that future services are less valuable than current services. In the situation where the cost of capital and the rate of return on capital are equal, the results of his method are identical to the compound-interest method. We will see later in this chapter that Lorig and Staubus achieve a similar result.

Basically, Bierman ties the calculation of depreciation to the calculations which were required in order to make the original decision to acquire the asset. Bierman states:

> It is the argument of this paper that it is possible to depreciate a long-lived asset in a reasonable manner which will give good results for comparing successive periods of a company's operations using either net operating income or return on investment.
>
> The depreciation charge is based on the expectations at the time of purchase. If after acquisition, management changes the method of operation, or economic conditions are not as forecasted, the depreciation schedule is not changed. However, the reported income and return on investment will differ from the planned figures, thus they will indicate where there is a need for investigation.[13]

Bierman introduces the cost of interest into the Revco model and illustrates its effect on the return on investment. He shows that if the cost of capital and the rate of return on capital are the same percentage, and if

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[13] Ibid., p. 618.

net cash proceeds are constant from year to year, that the return on investment will be a constant percentage over the life of the asset. In the author's opinion, a constant return on capital is a more reasonable result than the rapidly increasing return on capital, which is provided by the basic Revco method.

One of the major problems with Bierman's approach, which is also a problem of the basic Revco method, is in identifying net proceeds with specific assets. Bierman states that his method provides management with the opportunity of comparing actual results with the planned figures. In the author's opinion, in most situations the measurement of the contribution of specific assets is extremely difficult and somewhat arbitrary.

III ARTHUR N. LORIG[14]

Professor Lorig disputes Dixon's Revco concept. He does not agree that decreasing-charge depreciation should result from the discounting of future asset services, even when these services are constant from period to period. He does not agree that services to be received in later years are less valuable at the time of utilization than those received in the first year. He feels that there is

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[14]Arthur N. Lorig, "On the Logic of Decreasing Charge Depreciation," The Accounting Review, (January, 1962), pp. 56-58.

an increase in the value of services, as their time for use approaches, which would offset Dixon's discount.

According to Lorig, the purchaser of an asset should discount to the date of acquisition, the services he expects to receive from an asset over its life. However, the discount rate used, should be sufficient to cover only carrying costs. The discount rate would not include a gain. Lorig feels that the profit element is useful in making the original decision to invest but that it is not related to the cost allocation problem.

Lorig points out that if the discount rate is offset by carrying costs, and if asset service values are constant from year to year, the justification for decreasing-charge depreciation disappears. He rejects Dixon's method, or any other method which produces decreasing-charge depreciation in a situation where an asset produces constant service values over its life.

The author agrees with Lorig that carrying costs must be taken into account. If the cost of capital is ignored in the determination of the yearly depreciation charge, a double count will result. Depreciation charges will be high in the early years, at the same time that maximum carrying costs are being charged against income. Later in this chapter, Staubus will show that a discount rate which includes a profit element, tends to show a net income figure which increases both absolutely and as a percentage of

remaining asset value. Lorig's observation that decreasing -charge depreciation is not compatible with constant service values is borne out in Staubus' conclusion.

IV GEORGE J. STAUBUS[15]

Staubus extends Dixon's concept so as to illustrate its effect on net income and the rate of return on investment. Lorig's comments, with respect to the necessity of recognizing the cost of interest, are compatible with Staubus' presentation; however, Staubus goes into much greater depth with his illustration.

Staubus' presentation is really a case for the annuity method of depreciation; however, it is much more important to this study as an examination of Revco.

Staubus examines the following example provided by Dixon:

> Assume the purchase of a machine for $1,000 with an expected useful life of 10 years, and no salvage value. If the asset is capable of rendering an unchanged level of service throughout the ten years and if the purchaser is averaging a 10 percent after-tax return on assets, the $1,000 of cost should be assigned to the ten annual service components as follows (assuming a 50% tax rate):[16]

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[15]George J. Staubus, "Decreasing Charge Depreciation--Still Searching for Logic," The Accounting Review, (July, 1962), pp. 497-501.

[16]Ibid., p. 498.

TABLE XVII

REVCO AMORTIZATION

Year	Service Cost (Depreciation)	Percent of Total	Book Value
1	$ 200	20	$1,000
2	160	16	800
3	140	14	640
4	110	11	500
5	100	10	390
6	80	8	290
7	70	7	210
8	50	5	140
9	50	5	90
10	40	4	40
Totals	$1,000	100%	$4,100

The average investment is computed as $4,100/10 = $410. The average ten percent after-tax return on the asset is therefore $41 per year for ten years.

If the total net income after a 50% tax is $410, then the net income before tax must be $820, and the total return before depreciation must be $820 + $1,000 or $1,820.

Staubus feels that Dixon's assumption of an unchanged level of service over the ten year period suggests that the saving is the same each year. Table XVIII is constructed based on constant service values; however, Staubus points out a defect in the table. If the present value is computed at ten percent of the saving, less the income tax on

each line, they total only $908 when discounted at the desired earning rate. It is necessary to increase the present value of the gross after-tax flows by $92. Staubus notes that $92 is the present value of an annuity of $15 per annum for ten years at ten percent. He states that each year $15 should be added to the after-tax gross cash flow. In order to accomplish the $15 addition to the after tax column, $30 must be added to the column which is subject to the fifty percent tax. This data is presented in Table XIX.

Staubus feels that Table XIX is a more reasonable illustration of Revco. Furthermore, he feels that it corresponds closely to Dixon's intentions.[17] As in Dixon's model, the service values (savings) are constant over the life of the machine. The present value of the net cash flow is $1,000, based on a ten percent discount rate; which means that the owner will receive an average return of ten percent.

In order to illustrate Revco under different circumstances, Staubus prepared an illustration which eliminates

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[17]Staubus notes that one feature of Table XIX does not appear to be in accordance with Dixon's intentions. The service cost does not equal the savings discounted on either a ten percent or a twenty percent basis. If the owner of the asset is to earn ten percent after taxes, there is no particular reason why he should use a twenty percent Revco depreciation schedule.

TABLE XVIII[18]

REVCO AMORTIZATION

Year	Savings or Receipts	Service Cost	Net Income Before Tax	Income Tax	Net Income After Tax	Return on Investment
1	$ 182	$ 200	$ (18)	$ (9)	$ (9)	negative
2	182	160	22	11	11	1%
3	182	140	42	21	21	3
4	182	110	72	36	36	7
5	182	100	82	41	41	11
6	182	80	102	51	51	18
7	182	70	112	56	56	27
8	182	50	132	66	66	47
9	182	50	132	66	66	73
10	182	40	142	71	71	176
Totals	$1,820	$1,000	$820	$410	$410	

[18] *Ibid.*, p. 498.

TABLE XIX[19]

REVCO AMORTIZATION

Year	Savings or Receipts	Service Cost	Net Income Before Tax	Income Tax	Net Income	Return on Investment	Present Value of Receipts Less Tax
1	$ 212	$ 200	$ 12	$ 6	$ 6	1%	$1,000
2	212	160	52	26	26	3	894
3	212	140	72	36	36	6	797
4	212	110	102	51	51	10	701
5	212	100	112	56	56	14	610
6	212	80	132	66	66	23	515
7	212	70	142	71	71	34	421
8	212	50	162	81	81	58	322
9	212	50	162	81	81	90	223
10	212	40	172	86	86	215	115
Totals	$2,120	$1,000	$1,120	$560	$560		

[19] *Ibid.*, p. 599.

income tax and adds an interest charge on borrowed money. In the example, the asset yields services worth $100 per annum, assumed to be received at the end of each year. The asset was purchased for $421.24 to yield an average return of six percent on book value. The annual amortization is computed by the Revco method on the six percent basis. The interest cost is computed on the remaining balance of a five percent loan which financed the cost of the asset. Receipts are applied first against interest and capital.

Staubus made two main observations relative to his two Revco examples:

1. The net income figure has a tendency to increase both absolutely and as a percentage of the remaining asset value; and
2. The book value of the asset and the discounted value of its future net cash flow diverge except on the date of acquisition.

Staubus outlines the general characteristics of Revco:

> 1. The purchase price is divided into segments representing the cost of the services anticipated in each future period.
> 2. The division of the purchase price into segments requires knowledge of (a) the fractional portion of total services to be received in each period and (b) the appropriate discount rate.
> 3. The chosen discount rate is used in dividing the cost among the periods, and, hence, in determining the remaining amount of the asset; it is not used to determine the asset amount directly and the amortization indirectly. This means that the <u>change in the asset value</u> to be deducted on the

TABLE XX[20]

REVCO AMORTIZATION

Year	Receipts	Service Cost (Amortization)	Interest Cost	Net Income	Book Value	Return on Book Value	Present Value of Future Receipts
1	$100	$ 94.34	$ 21.06	$ (15.40)	$421.24	Negative	$421.24
2	100	89.00	17.11	(6.11)	342.30	Negative	246.51
3	100	83.96	12.97	3.07	259.41	3%	267.30
4	100	79.21	8.62	12.17	172.38	7	183.34
5	100	74.73	4.05	21.22	81.00	26	94.34
	$500	$ 421.24	$ 63.81	$ 14.95			

[20]*Ibid.*, p. 500.

income statement is treated as an independent variable which, together with beginning of period asset value, determines the revised asset amount. This general approach is currently popular among American accountants.

4. The method results in an increasing rate of return on asset values, other things remaining equal.
5. Interest is not included in the service cost.
6. The present value of future services concept of asset measurement is considered practicable for the purpose of deciding upon asset acquisitions, but is not utilized in subsequent balance sheet presentations.[21]

Staubus concludes that the Revco method of amortization is not acceptable.

Staubus provides a better analysis of interest cost than Bierman. Staubus shows in Table XX, that even with the inclusion of interest cost, that the rate of return on book value rises at an unrealistic rate over the life of the asset.

The author supports the following criticisms of Revco, which were made by Staubus:

1. That ignoring the cost of capital is a mistake;
2. That rapidly increasing income is unrealistic; and
3. That the balance sheet values are meaningless after the first year.

The above criticisms probably are the main reasons why many authors feel that the discounting technique, used to determine the feasibility of purchasing an asset

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[21] _Ibid_., p. 500

initially, cannot be used as the method to allocate the cost of an asset against income over its useful life.

V SUMMARY

In the introduction to this chapter the Revco method and the compound-interest method were compared. It was seen that, given constant service values, the Revco method resulted in decreasing-charge depreciation; whereas the compound-interest method resulted in increasing-charge depreciation. Revco provided identical annual depreciation charges to the compound-interest method, except they were in reverse order.

The question must be asked, "What are the relative merits of the two methods?" Conceptually, "How do they differ?"

First, let us examine the characteristics of the compound-interest method:

1. From a mathematical standpoint, it is an attractive package:

    a. The original cost of the asset represents the present discounted value of a constant stream of services plus the discounted value of scrap;
    b. The carrying value (book value) of the asset always represents the discounted value of the remaining stream of services and scrap value.[22]

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[22]Service values are assumed to be constant over the life of the asset.

c. The depreciation charge, each year, represents the input value of the asset's services in that year.[23]

2. It assumes that there is an implicit capital cost.

3. It results in a constant percentage rate of return on capital.

The basic Revco method, on the other hand, has the following characteristics:[24]

1. The original cost of the asset represents the present discounted value of a constant stream of services, plus the discounted scrap value;

2. The carrying (book value) of the asset after the first year <u>does not</u> represent the discounted value of the remaining stream of service and scrap value;

3. The depreciation charge represents the input value of the assets services that year, <u>based on the assumption that current services are more valuable than future services</u>;

4. The basic Revco method ignores the cost of capital; and

5. The basic Revco method results in an increasing

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[23]E.S. Hendriksen, <u>Accounting Theory</u>, (Homewood, Illinois: Richard D. Irwin Inc., 1965), p. 323.

[24]Bierman, Lorig and Staubus do not accept the basic Revco method because it does not take into account the cost of capital.

percentage rate of return on capital.

Dixon advocates the basic Revco method. He contends that future services are less valuable than present services mainly for two reasons:

1. The discount factor; and
2. His observation that assets become less efficient over time.

Bierman introduces the cost of capital into the Revco approach. He deals with both the cost of capital and the rate of return on capital, in his model. Where both rates are identical, his method achieves the same result as the compound-interest method. Where the rate of return on capital exceeds the cost of capital rate, he treats the difference as an unrealized profit.

Lorig does not accept the Revco method. He provides two reasons to support his contention that future services are not less valuable than present services:

1. The cost of services to be utilized immediately would be their purchase cost. However, the cost of future services would include the interest cost of capital tied up plus other costs such as insurance;
2. Discounting is an aid in making the initial decision to acquire an asset and nothing more.

Staubus examines Dixon's figures and makes the following observations:

1. The net income figure has a tendency to increase both absolutely and as a percentage of the remaining asset value;
2. The book value of the asset and the discounted value of its future net cash flows are not the same except at the date of acquisition.

It is the author's opinion that the Revco method is not an improvement on the conventional methods, including the compound-interest method. The argument that future services are less valuable than current services is not new to Revco; this argument has been made over the years by the advocates of the conventional decreasing-charge methods. The Revco method merely frames the concept in a mathematical formula.

The basic Revco method ignores the cost of capital. The failure to recognize the cost of capital represents a serious weakness in logic. If Revco's aim is to treat the asset as an investment which provides a specific, identifiable return: then all costs incurred in providing that return must be considered.

The introduction of the cost of capital into the Revco model by Bierman corrects the error, referred to in the previous paragraph. His acknowledgement that the cost of capital, and the rate of return on capital may differ, further improves the Revco concept. However, even after these adjustments are made, the Revco method has serious

shortcomings. It is not possible to adjust from year to year for obsolescence and other factors. The forecasts of profitability at acquisition date, may not hold true in the long run.

Regardless of whether or not interest costs are considered, the Revco method produces unrealistic income and asset figures. Income tends to start with negative values and to increase markedly, both absolutely and as a percentage of book value. Book value, on the other hand, does not represent the discount value of future services except at the date of acquisition.

CHAPTER VI

OPPORTUNITY COST THEORIES OF DEPRECIATION

This chapter examines depreciation theories based on the economist's concept of opportunity cost. According to the opportunity cost concept, the value of an asset's services is determined by assessing the costs or losses associated with the alternatives to ownership of an existing asset and by selecting the least costly of these alternatives to represent the value of the existing asset's services. The services of an existing asset cannot be more valuable than the least costly services provided by an alternative asset.

The body of this chapter deals with the work of two authors who base their depreciation concepts on the opportunity cost theory. First, Wright develops his concept in the circumstance where the utility value of an asset's services exceeds the value of services produced by its most economic alternative. In this situation a firm would continue to operate the existing asset and would value its services on the basis of replacement cost--replacement cost being the value of the services of the cheapest alternative. If utility value were less than the value of the services of the cheapest alternative, the firm would cease to operate the existing asset.

Wright continues the above assumption into a discussion of opportunity cost under conditions of economic stability. In this discussion he develops equations which express replacement cost as a constant service over the life of an asset. The condition of economic stability is then dropped and Wright examines opportunity cost in an economy where price changes and technological advancement occurs. As the result of introducing variable conditions, Wright finds it necessary to adjust his original equation so as to treat replacement cost as a marginal function.

Finally, Wright modifies his equations in an attempt to accommodate the problem of limited information. He attempts to provide a more generalized approach for the accountant.

Lowe discusses the interrelationship of capital cost, interest, depreciation and operating cost, from the viewpoint of an opportunity cost theoretician. He provides several illustrations which show the influence of physical deterioration, technological advancement and other factors on the shape of the depreciation curve. Lowe's paper is a good "follow up" to Wright's presentation, which is more concerned with the basic opportunity cost theory itself.

I F.K. WRIGHT[1]

[1]F.K. Wright, "Towards a General Theory of Depreciation," Journal of Accounting Reserach, (Spring, 1964), pp. 80-90.

Wright argues that the only proper approach to the theory of depreciation must be based on a theory of valuation. He suggests that there are two approaches to the problem of dealing with depreciation, the "accounting approach" and the "economic approach". The accounting approach requires that the cost of an asset be distributed over the life of the asset in a systematic and rational manner. The economic approach, on the other hand, ignores cost and considers the value of an asset at any point to be the sum of its discounted future services. Wright argues that the theory of depreciation must be based on a theory of valuation. The economist is concerned with "value-in-use" rather than "value-in-exchange."

Wright recognizes three main problems with the economic approach:

1. The problem of forecasting the future services of an asset;
2. The problem of valuing those future services;
3. The problem of determining the appropriate rate (or rates) of discount.[2]

Wright concerns himself mainly with the second problem.

Wright's theory is developed as follows:

> Reversing the well-known concept of opportunity cost we may say that their value is equal to the cost, loss or sacrifice which would have to be incurred if the firm did not have those services. Opportunity cost is measured by the most valuable alternative foregone; inversely 'opportunity value' (if we may coin

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[2] *Ibid.*, p. 82.

> a phrase) is measured by the least costly of the alternatives avoided through owning the services.
> The problem of valuing the services of an asset thus reduces to the problem of determining the alternatives to ownership of the asset, assessing the costs or losses associated with those alternatives, and selecting the least of those costs or losses to represent the value of the services.[3]

The alternatives to ownership of an existing asset may be divided into two groups:

> 1. Those which involve cessation of production of the services provided by the existing asset; and
> 2. Those which involve producing those services in some other way.[4]

The term "utility" is defined to mean the cost of the cheapest alternative in the first group. The term "replacement -cost" is defined to mean the cost of the cheapest alternative in the second group.

Wright states:

> The opportunity value of the services of an asset at any point of time will then be the lower of utility or replacement cost. Thus if the utility of the service is below its replacement cost, the value of the service to its owner will equal its utility; if the utility exceeds the replacement cost of the service, its value to the owner will equal its replacement cost.[5]

The value of the services of a new asset would be equal to their replacement cost. The utility of the services to the firm for a new asset would be so great that it would

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[3]*Ibid.*, p. 82.

[4]*Ibid.*, p. 82.

[5]*Ibid.*, p. 83.

be feasible to continue to provide them even if the new asset was destroyed accidentally. However, eventually the utility of the services of the asset would fall below replacement-cost. At this time, the services of the asset would no longer be required.

Replacement Cost Under Static Conditions

In order to illustrate his theory in simple terms, Wright assumes an economic situation where prices are stable and technology is static. He simplifies the illustration further by assuming that the utility of the asset's services, exceeds the replacement cost of its services. Given the above conditions, should an asset be accidentally destroyed, it would be replaced by an identical machine.

The condition of stability implies that the cost of an asset's services will be constant from period to period. Therefore, Wright defines replacement cost as "the (constant) average unit cost of obtaining the service from a hypothetical substitute for the existing machine."[6] In order to obtain the minimum average cost an asset would have to be operated for the optimum period of time.

Wright provides the following equation in which the minimum average cost can be determined by solving for R:

$$(1) \quad C = \sum_{n=1}^{T} [RQ(n) - E(n)] (1+i)^{-n} + s(T) (1+i)^{-T}$$

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[6] *Ibid.*, p. 83.

where

C is the capital cost of the substitute machine,
$Q(n)$ is the number of units of service produced by the machine during the n^{th} period of its life,
$E(n)$ is the operating expense incurred during that period,
i is the rate of interest, expressed as a fraction per period,
$S(n)$ is the salvage value of the machine at the end of the n^{th} period, and
T is the economic life of the machine, i.e., that life which leads to the minimum value of the average unit cost R.[7]

Based on the assumption of stable prices and static technology, the cost of the substitute machine and its production, operating expense and salvage value will be identical to the existing machine. In terms of equation one the value of C and the functions Q(n), E(n) and S(n), will be the same for both machines. With a slight rearrangement of equation one Wright formulates the following equation.

$$(2)\quad V(t) = \sum_{n=t+1}^{T} [RQ(n) - E(n)]\,(1+i)^{t-n} + S(T)(1+i)^{t-T}$$

which gives the value of the existing machine at the t^{th} period of its life; and

$$(3)\quad \begin{aligned} D(t) &= V(t-1) - V(t) \\ &= RQ(t) - E(t) - iV(t) \end{aligned}$$

which gives the depreciation cost for the existing machine for the t^{th} period of its life.[8]

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[7] *Ibid.*, p. 83.

[8] *Ibid.*, p. 84.

The above equations illustrate Wright's concept of constant opportunity values under conditions of stability. In the following section Wright examines opportunity value under variable conditions.

Opportunity Value Under Variable Conditions

Under variable conditions we no longer have constant-opportunity values from period to period. The replacement cost of a unit of service must be expressed as a function of time. Wright provides the following equation in which F(n) represents any cost function:

$$(4)\ C = \sum_{n=1}^{T} [F(n)Q(n) - E(n)](1+i)^{-n} + S(T)(1+i)^{-T}$$

where
F(n) is the cost of a unit of service from the machine, expressed as a function of time, and
T is the economic life of the machine, i.e., that life which maximizes the value of the right hand side of equation (4).[9]

Because there are an infinite number of functions F(n) which satisfy equation four, it is necessary to compare investments in terms of marginal value. Wright defines replacement cost as "that function which makes the most efficient machine available in each period appear as a marginal investment when its expended services are valued at the lower of utility or replacement cost".[10]

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[9] *Ibid.*, p. 83.

[10] *Ibid.*, pp. 84-85.

The difference between equations one and four is simply that equation one assumes constant service values, whereas equation four does not. Equation four is the final step in the development of Wright's concept. It enables one to deal with the depreciation problem under actual business conditions.

Although equation four completes Wright's theoretical treatment of the concept of depreciation, it has practical limitations. With limited information available to the businessman it is difficult to forecast the capital cost, operating costs, and production rates of the most efficient machine. Furthermore, these forecasts will be made on the basis of replacement cost up to the time that utility is less than replacement cost and on the basis of utility from that point forward.

The Intuitive Approach

Wright attempts to overcome the practical limitations of equation four through his intuitive approach. He feels that in broad terms one would expect the value of an existing machine's services to decrease with technological advancement, assuming constant prices. Conversely one would expect the value of an existing machine's services to increase in a situation where prices were rising and technology was static. Wright defined replacement cost "as that function of time which makes the most efficient machine available

appear as a marginal investment."[11] It follows therefore, that the machine for which we are attempting to determine a depreciation pattern would also represent a marginal function when its services are valued on the basis of replacement cost.

Wright provides equation five which determines the annual depreciation charge to be the drop in capital value of the future services of an asset, for which the future services were valued at estimated replacement cost.

$$(5) \quad D(t) = R(t)Q(t) - E(t) - iV(t)$$

Equation five differs from equation three only with respect to the R function. In equation three the R function is constant over the life of the asset; whereas in equation five the R function may have many values.

Comparison with Other Theories

Wright compares his theory, which is based on economics, to the discounted revenue method which resembles an economic theory. He notes that:

> Preinreich pointed out some years ago that the valuations to which it gives rise have objective validity only when the discount rate equals the opportunity cost of funds; book values obtained by discounting expected net revenues at any other rate are in fact based upon some (usually unrecognized) subjective assumption about 'the continuous time shape of the profit' from the investment.[12]

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[11] Ibid., pp. 84-85.

[12] Ibid., p. 87. Wright quotes G.A.D. Preinreich, "Annual Survey of Economic Theory: The Theory of Depreciation," Econometrica, Vol. 6 (July, 1938), p. 237.

Preinreich would rule out all depreciation methods where the time shape of profit did not terminate with an earning rate equal to the opportunity cost of funds. Wright, on the other hand, feels that Preinreich's observation would bother only a theoretical purist. Wright feels that the time shape implied by the discounted-revenue method may be reasonable.

One of the major problems with the discounted-revenue theory is in identifying revenue with the asset which produced it. In a plant where many machines and processes are necessary before the final product is completed, it may be impossible to measure the amount of service produced by each asset along the way. One method which attempts to overcome the problem of identifying asset services is the differential cash flow method.

The differential cash flow method attempts to relate revenues to the original investment decision. The reasoning is that if the revenues produced by each asset, calculated on the basis of the differential cash flow method, equals the total revenue recorded in a given period, there is some assurance that the revenue of the individual assets has been properly determined. The main objection to the discounted revenue approach is that the problems posed by the original investment decision are not the same as the problems posed by asset valuation.

The investment decision usually involves measuring

the cash flows of a proposed machine against the best alternative not involving capital expenditure. Wright states that differential cash flows computed in this way and discounted at the opportunity cost rate, will often result in values which are in excess of a machine's cost. Furthermore, the surplus of present value over cost does not necessarily mean that the machine should be bought: it merely shows that it would be preferable to buy the machine rather than to do nothing. Wright states:

> The essential difference between the cash flow of capital budgeting and our concept of opportunity value is simply this: differential cash flow is measured by comparing the situation which would result from a proposed capital expenditure with the best alternative available <u>without incurring capital expenditure</u>; opportunity value is measured by comparing the existing situation with the best alternative currently available, <u>whether that alternative involves capital expenditure or not</u>.[13]

II HOWARD D. LOWE[14]

Lowe categorizes the conventional depreciation methods into two groups:

1. Those which allocate cost to periods based on relative benefits expired; and
2. The compound-interest methods.

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[13]*Ibid.*, p. 89.

[14]H.D. Lowe, "The Essentials of a General Theory of Depreciation," *The Accounting Review*, (April, 1963), pp. 293-301.

He criticizes both methods in that they require arbitrary decisions regarding the method of cost allocation used.

Lowe presents a theory based on the economist's concept of opportunity cost. He argues that his theory is superior to the conventional methods because it takes into account a number of factors which the conventional methods either totally or partly ignore.

<u>The General Theory</u>

Lowe uses a manufacturing plant as his frame of reference. The total cost of operating a plant is divided into two parts as follows:

1. <u>The Capital Charge</u>, which is defined as the sum of the provision for depreciation and the interest related to the unrecovered funds remaining invested in the plant.
2. <u>The Current Cost</u>, which is defined as all other expenditures related to manufacturing operations.[15]

His general theory of depreciation is based on the following propositions:

1. The capital charge should be such as to make the total annual cost in every year no greater than the cost of the most economic alternative method of providing the same service.
2. The economic life of a plant is the period after which it is more economical to replace the plant than to continue to use it or the period after which the demand for the service ceases, whichever is shorter.
3. It is more economical to replace a plant than to use it only if the total annual cost after the replacement is less than the current cost before the replacement. The total annual cost

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[15] <u>Ibid</u>., p. 294.

after the replacement includes an appropriate capital charge on the cost of replacement while the current cost before the replacement excludes any capital charge related to the old plant.

4. The factors which limit the economic life of a plant are as follows:
   (a) Physical deterioration
   (b) Technological advancement
   (c) The level at which the plant is operated
   (d) The relationship of the total capital investment to the annual current cost
   (e) The rate of interest.[16]

Physical Deterioration

Lowe's general theory requires that the total annual cost of the existing plant should never be greater than the total annual cost of a new plant. This means that the total annual cost of a plant should be constant over its life, otherwise there would be times when the total annual cost of the plant under consideration would exceed the total annual cost of a new plant built to provide the same service.

As physical deterioration occurs, the current costs increase. In order to hold the total annual cost constant from year to year, it is necessary to decrease the capital charge by the same amount that the current cost increases. This means that the capital charge must be calculated so as to redeem the plant investment by the time the current cost equals the total annual cost. At that time, the capital charge would equal zero.

It is assumed that an investment of $100,000 is

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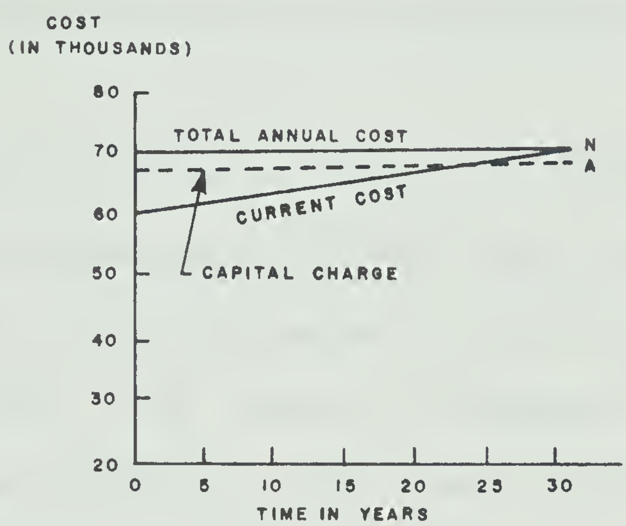
[16] *Ibid.*, pp. 294-295.

made in a hypothetical plant. The current cost at the beginning of the first year is $60,000 and increases by one-half percent per annum. A yearly interest rate of five percent is assumed.

FIGURE IV[17]

CONSTANT TOTAL ANNUAL COST



Original capital investment = $100,000
Initial current cost = $60,000
Rate of increase of current cost = ½% per year
Rate of interest = 5%
Constant level of operations.

Referring to Figure IV, the total annual cost in each year is $70,248. Point N, which corresponds to year 32 on the horizontal scale, is the end of the asset's life. At the end of the first year, the current cost is $60,300

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[17] Ibid., p. 296.

and the capital charge is $9,948 ($70,248--$60,300). The capital charge has two components; the interest charge on capital investment and the provision for depreciation. The provision for depreciation is determined by subtracting the interest charge from the capital charge. In the first year the interest charge is $5,000 (five percent of $100,000) and therefore the provision for depreciation is $4,948 ($9,948--$5,000). By the twentieth year the capital charge is $3,954.

Broken line AA in Figure IV shows what would happen if the total annual cost of the most economic alternative was less than the total annual cost of the plant under consideration, due to an error in judgment made when the existing plant was acquired. The result would be that the existing plant would be replaced in 27 years, as shown by location N^1. Lowe would write-off the capital loss immediately and bring the total annual cost down to level AA.

The author agrees with Lowe that it would be more logical to write-off immediately, capital losses which are attributable to errors in judgement. However, the author would want to make certain that technological advances subsequent to the date of the original valuation were not the real cause.

Where the total annual cost of the most economic alternative plant is greater than the total annual cost of the existing plant the competitive market would soon bring

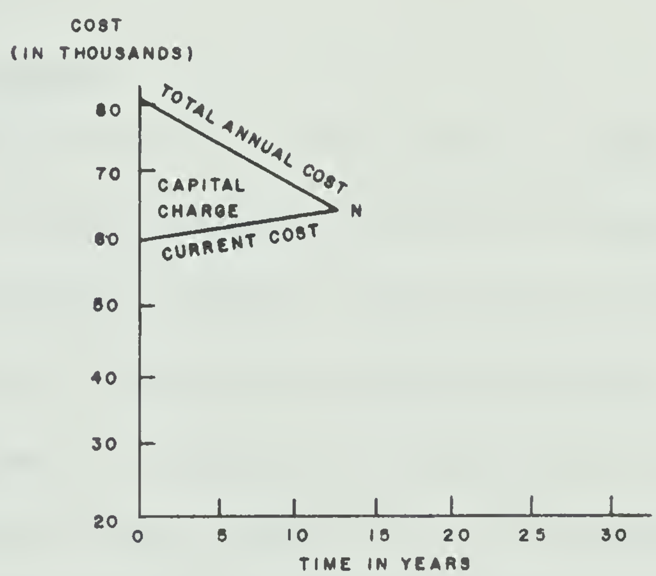
it into line.

Technological Advances

Technological advance reduces the total annual cost of a new plant capable of providing the same service as the existing plant. According to Lowe's method this means that the capital charge for the existing plant must decrease each year so that its total annual cost will not exceed the decreasing total annual cost of a new plant constructed in the future.

FIGURE V[18]

DECREASING TOTAL ANNUAL COST



Initial current cost = \$60,000
Rate of increase of current cost = ½% per year
Rate of interest = 5%
Rate of decrease of total annual cost = 2%
Constant level of operations.

[18] Ibid., p. 297.

The existing plant should be replaced at point N, in thirteen years. At this point, the current cost of operating the existing plant approaches the total annual cost of operating the most economic alternative plant. Figure V shows that the effect of technological advance is to increase the total cost of the asset in the early years and to shorten its economic life. The total cost, which is $82,180 at the end of the first year, decreases by two percent per year up to the end of the thirteenth and final year. The capital charge at the end of the first year is $20,235, of which $5,000 represents interest (five percent of $100,000) and $15,235 is the amount of the provision for depreciation.

Level of Operations

According to Lowe, the level of plant operations has an effect on the economic life of a plant. Accordingly Lowe's general theory adjusts the rate of depreciation to different levels of operation automatically.

If a plant is operated at partial capacity, its operating costs are less than if it is operated at full capacity. This is so because operating costs are for the most part variable in nature. If a plant is operating at less than full capacity the annual percentage rate increase in operating cost will not change; however, the dollar increase will be smaller because the percentage increase relates to a smaller base. The effect of the reduced dollar increase

will cause the current cost curve to intersect the total annual cost curve at a more distant point on the horizontal axis. The life of the plant will be extended.

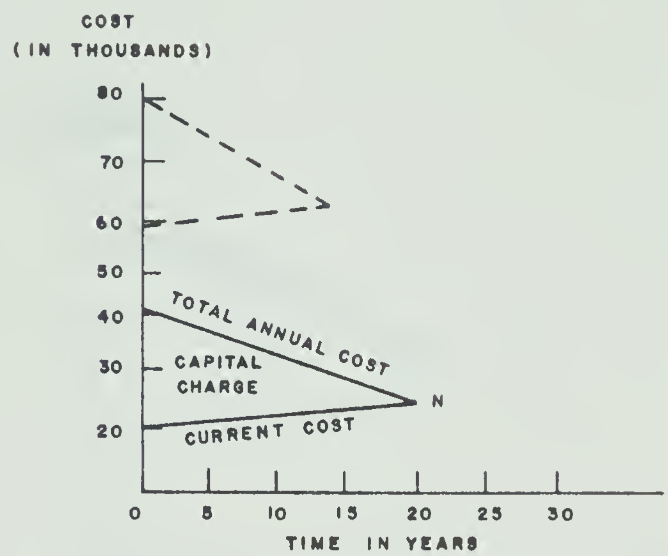
Figure VI illustrates the effect of reduced operations on the economic life of a plant and on its capital charge. The data are the same as in Figure V except that the level of operations is reduced by roughly one-half and the current cost for the first year is $30,000. According to Lowe's calculations, the economic life of the plant is extended from thirteen to eighteen years and the capital charges for the first two years are $17,528 and $16,424 respectively. The provision for depreciation in the first two years is $12,528 and $12,050 respectively.

By cutting the operating level in half, we see that by comparison with the situation presented in Figure V, the capital cost is reduced by $2,707 in the first year and the economic life of the plant is extended by five years.

Intuitively one would agree with Lowe's conclusion that the economic life of a plant would be extended if the level of production was reduced. Reduced physical activity would likely result in reduced physical deterioration caused by wear and tear. From the financial standpoint the plant would have to be operated for a longer period of time in order to recover capital costs.

FIGURE VI[19]

REDUCING ANNUAL COST WITH A DECREASE IN LEVEL OF OPERATIONS



Same data as in Figure V except the initial cost is $30,000 instead of $60,000.

Capital Investment

According to Lowe's theory the economic life of a plant is affected by the combination of the use of capital and current costs. By increasing capital investment, it is sometimes possible to reduce current costs. The increased investment extends the economic life of the plant.

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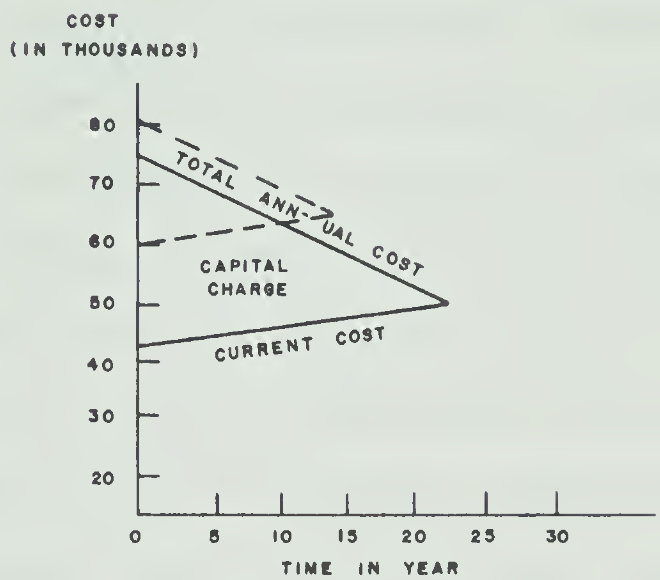
[19] *Ibid.*, p. 297.

FIGURE VII[20]

REDUCING TOTAL ANNUAL COST-SUBSTITUTION OF CAPITAL INVESTMENT FOR CURRENT COSTS



Original capital investment = \$175,000
Initial current cost = \$45,000
Rate of increase of current cost = ½% per year
Rate of interest = 5% per year
Rate of decrease in total annual cost = 2%
Constant level of operations.

Figure VII assumes the same data as in Figure V except that current costs are reduced by 25 percent as the result of increasing the total capital investment by 75 percent. The economic life of the plant is increased by seven years and the total annual cost is reduced by eight percent.

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[20] *Ibid.*, p. 298.

SUMMARY

The opportunity cost theory of depreciation represents a radical departure from the conventional cost methods. Opportunity cost is a more subjective concept in that it is based on utility or usefulness, rather than on historical cost. The opportunity cost approach also differs from the conventional methods with respect to flexibility. The conventional methods determine the depreciation pattern at the time the asset is acquired, and then hold to this pattern over the life of the asset; whereas, the opportunity cost approach requires periodic appraisal and adjustment.

Although the opportunity cost approach is somewhat subjective, it is easy to grasp conceptually. The premise, that the value of the services of an existing asset are equal to the value of the services of the least costly alternative, is logical. Opportunity cost is the price that the owner of an asset would pay to replace an asset should it be suddenly destroyed. Opportunity cost is also the price a competitor would pay to acquire the same services. Opportunity cost is the market price of the least costly alternative.

The important aspect of Wright's presentation relates to his discussion of "utility" and "replacement cost," rather than to his equations. It is essential to grasp the relationship of utility and replacement cost in order to understand the opportunity cost concept. Wright's equations,

which illustrate opportunity cost under stable economic conditions and then under variable economic conditions, merely discount future service values so as to arrive at a depreciation figure. His equations are similar to the discounted-revenue equations, with the exception that he uses opportunity value rather than revenue.

Wright's intuitive approach represents a compromise between theory and practice. Wright recognizes that it would be difficult to provide the forecasts required in equation four; consequently, he suggests an approach based on broad expectations. Equation five determines the annual depreciation charge as being equal to the drop in an asset's capital value, with future services being valued at their estimated replacement cost.

Lowe's theory of opportunity cost is the same as Wright's; however, Lowe places more emphasis on the factors which influence the depreciation pattern. Lowe views total annual plant costs as being composed of two elements--capital cost and current cost. Capital cost includes depreciation and interest on invested capital, whereas current cost includes all other operating costs. Based on these two classifications, Lowe shows the effect of factors such as physical deterioration and technological advancement, on the shape of the depreciation curve and on the life of the asset. Although Lowe provides little argument in support of his conclusions, he does provide insight into the influence

of the above factors, on the shape of the depreciation curve.

In the author's opinion, the opportunity cost approach has the following advantages:

1. It requires an annual appraisal of values, consequently it takes into account happenings subsequent to acquisition date;
2. Factors such as obsolescence are adjusted for automatically each year;
3. Utility value is probably more meaningful to management than cost value. Management is interested in value from an operating standpoint; and
4. The annual calculation serves as a guide to management in deciding whether or not to continue to use an asset, replace it, or abandon the whole project.

The opportunity cost approach has these disadvantages:

1. It is not always possible to locate an alternative asset; and
2. It is necessary to make forecasts of capital cost, operating costs, and production rates of the most efficient alternative asset. Such figures are usually not readily available.

In the author's opinion, the opportunity cost approach

to the depreciation problem is a step in the right direction. The opportunity cost approach differs from the conventional methods in that opportunity cost is based on a different kind of value. Any comprehensive discussion of depreciation policy must necessarily revolve around the definition and measurement of value. If there is to be continued improvement in the field of depreciation thought and policy, effort must be directed to the problem of valuation.

CHAPTER VII

SUMMARY AND RECOMMENDATIONS

I THE PURPOSE OF THIS STUDY

The primary purpose of this study is to provide a better understanding of the problem of accounting for depreciation. The research method used was to approach the subject through an examination and classification of the major schools of thought.

II THE CONVENTIONAL DEPRECIATION METHODS

The conventional depreciation methods are based on cost-value. Their aim is to allocate the acquisition cost of an asset to revenue in a systematic and rational manner over the asset's useful life.

Where depreciation is based on historical cost, as it is with the conventional methods, the main emphasis is placed on the income statement. The prime purpose of depreciation is considered to be for the determination of income. The balance sheet assumes secondary importance because the net asset values shown thereon do not represent meaningful value. Asset values have significance only on the day on which the asset is acquired.

The conventional definition of depreciation is a

static concept. The estimates which are made are assumed to remain constant over time. Although this assumption tends to simplify the problem, to a certain extent, each estimate is based on multiple probabilities, and their expression as a single value is difficult.

A THE CONVENTIONAL NON-INTEREST METHODS

The common characteristic of the conventional non-interest methods is that they are based on cost. However, they differ regarding the assumptions they make about service value. The straight-line method assumes, for example, that service value declines as a function of time. The variable-charge methods, on the other hand, assume that the service value of an asset declines as a function of use.

The decreasing-charge methods assume that the efficiency of an asset decreases with age. Service values are not a function of time as they were with the straight-line method. Although time is a factor, other considerations such as repair and maintenance costs and uncertainty are considered to be the important determinants of service value.

The straight-line and the decreasing-charge methods are by far the most common methods in use today. The decreasing-charge methods have gained in popularity in recent years because of a growing conviction that asset efficiency decreases over time.

B THE CONVENTIONAL INTEREST METHODS

The following depreciation methods, which were examined in Chapter III, are referred to here as the conventional interest methods:

1. The compound-interest method;
2. The annuity method;
3. The sinking fund method; and
4. The decreasing-charge interest method.

The conventional interest methods view an asset more as an investment value than as a physical value. They take into account the cost of capital.

The compound-interest, annuity and sinking fund methods have one thing in common with the straight-line method; they assume that service values are constant over the life of the asset. The annual depreciation charge differs, however, because of the interest factor.

The decreasing-charge interest method simply incorporates the idea of decreasing asset efficiency into the compound-interest model, with the result that annual depreciation charges decrease.

The compound-interest methods result in a constant rate of return on capital. Many utility companies favour the compound-interest methods for this reason. These companies are usually in the position of having to defend their rate structure relative to the rate of return on investment. Consequently, they wish to avoid large fluctuations in income.

With the heavy investment in plant, which is a characteristic of the industry, the depreciation charge has an important bearing on the determination of net income. The main criticism of the interest methods of depreciation relates to their assumption that service values are constant over the life of an asset. Many authors feel that repair and maintenance cost increases and efficiency declines over an asset's life. The interest methods are not necessarily more dynamic because they include one more factor--the cost of capital.

III THE CONTEMPORARY INTEREST METHODS

A THE COMPOUND-INTEREST METHODS

The advocates of the contemporary interest methods stress that the proper approach to the depreciation problem is to first determine the pattern of an asset's net service value, and then to determine the relationship of depreciation to the net service value curve. The recognition of the importance of the relationship of net service value to depreciation is not new; what has changed is that there is now more emphasis placed on it. The conventional methods made arbitrary assumptions about the shape of the net service value curve, whereas, the contemporary approach is much more precise.

Net service value is defined as that part of revenue contributed directly by the plant asset, less all operating

costs other than depreciation. There is no general agreement on the relative importance of the factors which affect net service values; however, the following list, provided by Reynolds, would probably receive general acceptance:

1. The trend of operating costs;
2. The physical efficiency of the asset;
3. The amount of competition which may be expected from improved alternatives; that is to say, the gradual encroachment of obsolescence and inadequacy; and
4. The expected rate of use of the asset.[1]

The measurement of net service values is difficult; however, it can be approached in several ways. Terborgh attempted to measure the decline in asset values by doing a survey of the decline of resale value of equipment and then using the resale values as the value criterion. Battista and Crowningshield attempted to estimate future net service values at the time the asset was acquired. Battista and Crowningshield based their theory on the premise that if an asset is to be profitable it must produce revenues large enough to cover:

1. The interest cost of the asset;
2. A return on capital invested; and
3. Repair costs.

The compound-interest approach is sometimes considered to be the theoretically correct approach for the following reasons:

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[1] Isaac N. Reynolds, "Selecting the Proper Depreciation Method," Accounting Review, (April, 1961), p. 239.

1. The original cost of the asset represents the present discounted value of a constant stream of services plus the discounted value of scrap value;
2. The carrying value (book value) of the asset always represents the discounted value of the remaining stream of services and scrap value; and
3. The depreciation charge each year represents the input value of the asset's services in that year.[2]

B THE REVERSE COMPOUND-INTEREST METHOD (REVCO)

The Revco method assumes that future services are less valuable than current services. There are two main reasons for the assumption:

1. The observation that the efficiency of an asset declines rapidly in the early years of its life; and
2. The theory that the present value of most distant service is less than the present value of immediate service, because of the discounting factor.

The two factors produce decreasing annual depreciation charges.

The major weakness of the Revco method is that it does not take into account the cost of capital. It is suggested by several authors that the cost of capital should be incorporated into the Revco concept. The basic Revco

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[2] E.S. Hendriksen, Accounting Theory, (Homewood Illinois: Richard D. Irwin Inc., 1965), p. 325.

model does not find much favour among the contemporary authors. The theory that distant services are less valuable than future services finds little support. Generally, it is felt that the discounting technique, which is useful in determining the original value of the asset, is not meaningful beyond that point. It is argued that when the time comes to use a service it will be just as valuable at that time as the service used in previous years.

IV THE OPPORTUNITY COST METHODS

The depreciation methods described in Chapters III, IV, and V are based on cost-value, whereas the opportunity cost concepts of Chapter VI are based on use-value or utility.[3] This represents the largest conceptual difference between any of the depreciation methods discussed in this study.

The opportunity cost approach should not be confused with the discounted revenue approach. Although both methods apply the discount technique, the opportunity cost approach discounts utility value, whereas the discounted revenue approach discounts revenue.

Other than for the above similarity, the two

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[3]Chapter II lists the following types of value:
1. Cost-value;
2. Exchange-value;
3. Esteem-value; and
4. Use-value.

approaches are very different. The discounted revenue method compares several alternatives at the time the acquisition of the asset is considered. The asset which has the highest surplus of present value above cost is chosen. Future annual depreciation charges then follow from this calculation. The opportunity cost approach produces another dimension. It not only compares a proposed asset with other assets, it also considers the alternative of no investment.

The price-level problem is more easily dealt with within the framework of the opportunity cost approach. Utility is automatically expressed in current dollars.

The opportunity cost method is more difficult to apply than the conventional methods or the contemporary interest methods. The difficulty arises from the fact that use-value is more subjective than cost-value.

V OPINION

From a theoretical standpoint, the opportunity cost concept is probably superior to the other concepts discussed in this study. However, it is a difficult concept to apply. The problem here, which is applicable to all depreciation concepts, is in assessing the theoretical and practical aspects of each concept.

Theoretical matters should not be judged by their practicality but on the basis of the light they shed on a subject. Practical methods, on the other hand, have some

theoretical basis and consequently require theoretical appraisal. It is obvious that the theoretical aspects should be considered first.

Generally, the businessman is not interested in, nor does he have time for, research in great depth. His preference is for methods which appear to be reasonable and rational, and which are easily applied. The conventional depreciation methods have evolved to satisfy this requirement.

There is a problem of dialogue between those who favour the generally accepted methods and the theoreticians. The practitioners favour the "easy way out", whereas the theoreticians often fail to consider the problems of application. One author who attempts to consider both sides of the problem is Wright. His paper, which is discussed in Chapter VI, recognizes the problem of application and suggests an approach which could produce results in line with his theoretical goals.

VI AREAS FOR ADDITIONAL RESEARCH

Throughout the research phase of this study, a number of possible avenues for further research were encountered. In the author's opinion, research in the following areas would be worthwhile:

1. A study of the history of the development of depreciation theory from the mid 19th Century

to the beginning of World War Two. This period saw the development of the conventional depreciation concepts. This was largely in response to the demand for better accounting brought on by the growing public corporations, mainly in the railroad and utilities fields. Much of the early history is recorded in the court cases of the United States and Great Britain.

2. An "in depth" study of developments in the theory of depreciation since the Second World War. The theory of this era has been influenced by the problem of inflation and to some extent by income tax considerations.
3. Empirical studies to determine the level of acceptance of theories such as current replacement cost and opportunity cost.
4. Empirical studies to determine the importance of factors such as physical deterioration and obsolescence on general asset groupings. The accounting records of most corporations do not provide much information in this area.

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